The Blast Furnace and Steel Plant

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CONTENTS

Page
EDITORIAL 157
LORRAINE IRON DEPOSITS—By Olin R. Kuhn 158
COMBUSTION IN O. H. FURNACE WITH SPECIAL REFERENCE TO AUTOMATIC CONTROL—By K. Huessener 162

THE SAFETY CRUSADE—

DEPENDABLE GAS VALVES—By F. J. Crolius 169
GENERAL PRINCIPLES OF THE BENEFICIATION OF IRON ORES—By T. T. Read 172

SHEET AND TIN PLATE—

THE BLISS "CLUSTER" MILL—By Lloyd Jones 180
LINING FURNACE BUNGS—By Meredith F. King 181

CURRENT REVIEW—

THE MANGANESE SITUATION 182
CURRENT LITERATURE ON FERROUS METALLURGY—By E. H. McClelland 185
COMMUTATION TROUBLES IN D. C. MOTORS—By Earl B. Stavely 189

THE POWER PLANT—

VISUALIZED BOILER OPERATION—By John D. Hiles 193
MANGAN. STEEL SHEAR KNIVES FOR HOT WORK—By Edwin R. Norris 195
CENTRAL FURNACE TO SINTER DUST 196
WITH THE EQUIPMENT MANUFACTURERS 197
TRADE NOTES AND PUBLICATIONS 200
OPEN HEARTH PAGE 202
NEWS OF THE PLANTS 203
BY-PRODUCT AND CHEMICAL NEWS 204

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The Blast Furnace and Steel Plant

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Man's Most Helpful and Constant Companion—Steel

STEEL is slowly and carefully developed from iron ore. We have learned that its possibilities for man's use are unlimited ¶ Its disposition can be changed by heat or cold. Some steels have a temper, as the blades of our knives. Sometimes steel is indifferent and will not do what we have a right to expect of it. Occasionally it snaps or breaks, due to some oversight during its educational period.

But for thousands of purposes it is superior to any other known material, for it possesses those fine qualities of strength and texture which can only result from careful preparation. In nearly every instance, steel will reflect credit on those who have devoted their time and energy to the forming of its disposition.

Again, steel is like a human being, for it has life. It is made from iron ore taken out of the mine. If neglected, it returns to the same form from which it came. Its period of usefulness is the LENGTH of its LIFE. Life is, of course, of utmost importance. It is necessary that the articles of steel we buy possess the greatest possible usefulness. Chemists and other scientific men have devoted much time and energy for many years in the hope of prolonging the life of steel.

Their efforts were rewarded about seventeen years ago when it was found that an alloy of copper and steel would at least double the life of thin sections, such as sheets and plates. Today, many of the leading manufacturers are making their principal products from copper alloy steel.

This achievement was a great step forward in conserving our natural resources of iron ore, which we know must be taken out of the earth's crust, to be moulded and refined until the finished product becomes man's most helpful and constant companion—Steel.

—Walter Carroll in "Making Steel."

Lorraine Iron Ore Deposits

Continuation of a Series of Articles Entitled "Iron Ores of the World"

By **OLIN R. KUHN***

THE Lorraine Basin in eastern France is one of the five largest deposits of iron ore known today and is the second largest producer. This vast iron ore field is the mainstay of the European iron industry and has always been a source of contention between France and Germany. Prior to 1878 these ores were only used to a small extent and the deposits belonged to France. After the Franco-Prussian War, Germany took the Lorraine Annexee or Alsace-Lorraine where they believed the only valuable ore to be. Afterwards France explored and developed the Briey, Longwy, and Nancy basins in French Lorraine and with the signing of the Versailles Treaty in 1919, the Lorraine Annexee again reverted to France. This gave France virtual control of the iron ore of continental Europe, while Germany to a large extent controls the coking coal. For this reason, in order to obtain the maximum from their iron industries, France and Germany will have to "pull together" and come to some agreement whereby Germany will ship coal to France and France in return will ship iron ore to Germany.

The Lorraine Basin lies in the eastern part of France and includes the Longwy, La Crusnes, Briey, and Nancy basins, the area between the Fentsch and Orne rivers, and the Aumetz-Arsweiler plateau. These latter fields are called the Lorraine Annexee and prior to 1919 belonged to Germany. The Lorraine Basin extends up into Belgium and Luxemburg but the deposits there are quite small when compared with the rest of the field. The entire Lorraine iron ore field covers an area of about 295,000 acres or 500 square miles and contains a reserve of over 5,500,000,000 tons of ore. Although the ore in these deposits only carries from 24 to 41 per cent of iron, they are the most valuable deposits in Europe on account of their enormous reserves, easy accessibility, suitable composition, low mining cost, and closeness to the coal fields.

The ores are of sedimentary origin, occurring as beds in the Toarcian formation of the Jurassic system, and the iron bearing zone ranges from 75 to 175 ft. in thickness. The beds have a general westerly dip of three degrees or less and the ore is mined by both open pit and underground methods. The ore fields are intersected by a number of faults which strike in a northeasterly direction and are parallel to the many shallow anticlines and synclines which occur in the field. There are eight distinct beds throughout the Lorraine Basin but in many places only one is worked. The beds worked vary from a few feet to a great thickness and generally speaking they tend to depreciate in thickness and quality in a southwesterly direction. The different beds are separated from each other by blue and grey marls and are distinguished by their respective red, brown, black, yellow, green, and grey colors.

Hanging Wall Bed....	Hanging Wall Marl Red Sandy Bed
Middle Calcareous Bed	Red Calcareous Bed Yellow Bed Grey Bed
Lower Siliceous Group.	Brown Bed Black Bed Green Bed Footwall Marl

The grey bed is the most important and is the most regular in composition, thickness, and extent. The yellow and red beds contain calcareous ore while the black, brown, and green beds are characterized by the amount of silica they contain. The grey bed is mined in practically every district and varies from 6 to 17 ft. in thickness.

The ore is an oolitic hematite called minnette ore and consists largely of iron oxide with smaller amounts of ferrous carbonates. The matrix in which these oolitic particles are set is either calcareous or siliceous. These minnette ores are described as hydrated or brown hematites and vary from 33 to 40 per cent in iron content. The ore is high in phosphorous but is well adapted for use in making pig iron suitable for the Basic Bessemer process. The physical structure of the ore is satisfactory but attempts to enrich it by roasting break down the structure and it falls to pieces.

From 1871 the production of minnette ores increased slowly until 1913 when the maximum production of over 48,000,000 tons was reached. During the War and since then the production of these ores has fallen off considerably but in the near future production should again be up to normal and it will probably not be many years before the minnette ores are being mined at the rate of over 70,000,000 tons annually. In 1913 about 39,000 miners were employed in the Lorraine ore field and at present the total capacity of the furnaces using Lorraine ores is estimated at 43,500,000 tons of pig iron.

CONSUMPTION OF LORRAINE BASIN ORES—1913

Consumed by	Tonnage
Lorraine—French	10,508,400
Other French Districts	2,002,000
Belgium	6,404,450
Luxemburg	8 534,850
Lorraine Annexee	13,075,760
Westphalia—Germany	4,439,350
Sarre District—Germany	3,052 240
All others	76,000
Total	48,093,050

French Lorraine.

The French Lorraine district comprises three principal fields of which the Briey Basin is by far the largest. The Longwy field lies to the north and the Nancy field to the south of the Briey Basin. Between the Briey and Longwy fields is the little developed Crusnes field which is generally included in the Longwy basin. The Briey Basin is divided into three fields, Orne, Landres, and Tucquegnieux districts.

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*Buffalo, N. Y.

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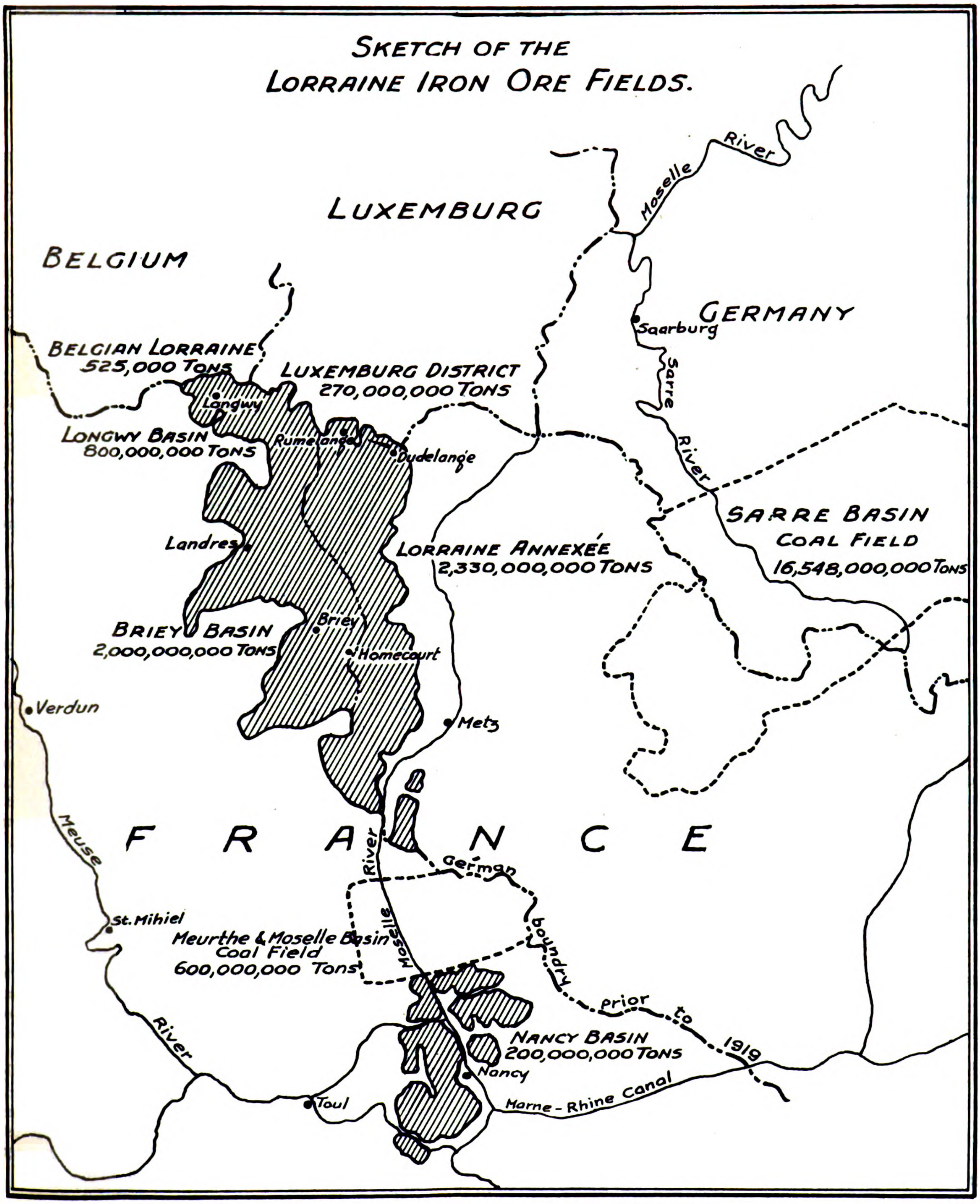
SKETCH OF THE
LORRAINE IRON ORE FIELDS.
LUXEMBURG
BELGIUM
GERMANY
Moselle River
Saarburg
Sarre River
BELGIAN LORRAINE
525,000 TONS
LUXEMBURG DISTRICT
270,000,000 TONS
Longwy
LONGWY BASIN
800,000,000 TONS
Rumelange
Dudelange
SARRE BASIN
COAL FIELD
16,548,000,000 TONS
Landres
LORRAINE ANNEXÉE
2,330,000,000 TONS
BRIEY BASIN
2,000,000,000 TONS
Briey
Homecourt
Verdun
Metz
F R A N C E
Meuse
River
German
boundary
prior
to
1919
St. Mihiel
Meurthe & Moselle Basin
Coal Field
600,000,000 Tons
Moselle
NANCY BASIN
200,000,000 TONS
Nancy
River
Toul
Marne-Rhine Canal

Briey Basin—The Orne district lies to the south of the Avril fault in the Briey basin. The grey seam, which is the only seam workable in this district, ranges from 9 ft. 10 inches to 16 ft. in thickness and the iron content of the ore varies from 34 to 40 per cent. The seam thins out and becomes poorer towards Conflaus. The ore is freely calcareous except toward the west where the silica becomes higher. The green seam appears workable towards Homecourt and Montiers, the black towards Giraumont, the yellow and red at Joeuf and Homecourt, the yellow at Auboue and Valleroy, and the red at Montiers. The lower seams or beds are usually siliceous and the upper seams chalky.

The Landres district, to the west of the Bonvillers and Norroy faults, has an elongated elliptical shape about 7½ miles long by 3½ miles wide. The grey seam is the only one worked in this district and varies from 16 ft. 6 in. to 29 ft. 6 in. in thickness except in the western part where it is only from 10 to 13 ft. thick. The footwall of the seam lies from 590 to 787 ft. below the surface.

In the Tucqueguieux district the grey seam predominates and varies from 20 to 23 ft. in thickness. The ore is fairly high in iron and the gangue in distinctly calcareous. Near Audun the brown, black, and green seams are encountered although seldom together and they are fairly siliceous. The red seam is of interest towards Anoux.

The reserve of the Briey Basin is estimated at about 2,000,000,000 tons and 75 per cent of the ore mined in French Lorraine comes from this field. The ore in the Briey district usually lies from 600 to 750 ft. below the surface and can only be reached by shafts. Considerable water is encountered in this district which necessitates much pumping.

Longwy Basin—The Longwy Basin forms a band along the northeastern border of Meurthe-et-Moselle. It is composed of seams easily reached by simple cross-cuts and sometimes even workable by open pits near Hussigny. The seams are usually calcareous except the yellow and red which are always siliceous. West of the Longlaville fault only the grey seam occurs, between Longlaville and Godbrange the yellow and red seams can be mined, and to the east of Gogbrange the red, black, grey, and green seams are found. The seams vary from 3 ft. 3 in. to over 13 ft. 1 in. in thickness and the iron content of the ore averages from 32 to 40 per cent and the silica from 13 to 20 per cent.

The reserve of the Longwy and Crusnes districts is usually taken at 800,000,000 tons and the production averages about 2,500,000 tons annually.

Crusnes Basin—The Crusnes Basin lies between the Landres district and the Longwy basin of which it is a prolongation. A few concessions were granted in this field in 1912 but as yet none have been worked. On account of the depth of the ore bed in this field, from 330 to 490 ft., the mining will all have to be done underground. The ore is usually siliceous. The grey seam occurs over an extensive area and varies from 6 ft. 7 in. to 16 ft. 5 in. in thickness, containing from 30 to 36 per cent of metallic iron.

Nancy Basin—The Nancy basin outcrops in the depressions formed by the valleys of the Meurthe and Moselle Rivers and extends toward the west. Only three seams are known throughout this district and they are called the Upper, Middle, and Lower beds. They are generally not over 6 ft. 7 in. thick and do not always occur simultaneously in the same region. The ore is generally siliceous containing from 12 to 16 per cent of silica and the iron content rarely exceeds 37 per cent.

The production of the Nancy basin is only from 500,000 to 2,000,000 tons annually and the reserve is estimated at about 200,000,000 tons.

French Lorraine produces 15,000,000 to 20,000,000 tons of iron ore annually and the reserve of this basin is close to 3,000,000,000 tons. Fifty per cent of the ore mined in French Lorraine is consumed locally, the balance prior to 1914 was shipped to Belgium, Luxemburg, and Germany. In 1913 the mining costs of French Lorraine ore was 3.80 francs, about 75c a ton. Of course the cost of these ores has greatly increased over the last 10 to 12 years, but it is still quite low. There are about 90 blast furnaces in French Lorraine practically all of which are owned by French capital and the production of pig iron is about 3,500,000 tons.

Lorraine Annexee.

Prior to 1919 the Lorraine Annexee ore fields belonged to Germany but they are now French territory. These deposits, about 100,000 acres, contain ore very similar to those of the French Lorraine districts. The ore occurs in beds ranging from 6 to 18 ft. in thickness and in most places there is only one workable seam, in others there are three or four. The ore is oolitic limonite carrying from 26 to 40 per cent of iron and that in the southern part of the field is siliceous while the ore in the northern part is calcareous. The mining is done by adits and shafts which are from 600 to 750 feet deep.

The reserves of the Lorraine Annexee is estimated at from 1,800,000,000 to 2,500,000,000 tons and the production was about 20,000,000 tons annually, most of which was used by Germany. At present the production is only about 10,000,000 tons per year. About half of this ore is consumed locally and the balance is shipped to Germany and Luxemburg. There are 80 blast furnaces in this district which have an annual capacity of about 4,000,000 tons of pig iron. The cost of mining Lorraine Annexee ores in 1913 varied from 2.40 francs for adit mining to 4.10 francs for shaft mining.

Luxemburg.

The Luxemburg deposits of the Lorraine Basin are divided into two parts, called the Differdange deposits and the Rumelange deposits. The Differdange deposits contain only siliceous ore carrying from 28 to 41 per cent of iron and the Rumelange deposits contain calcareous ore carrying from 17 to 27 per cent of iron. In 1913 Luxemburg contained 95 mines about half of which were open pits. The production of Luxemburg is from 3,000,000 to 7,000,000 tons annually most of which is consumed by Luxemburg and Belgium. The reserve of Luxemburg is estimated at from 250,000,000 to 270,000,000 tons and in 1913 the cost of production was under 65c per ton. The average iron content in these ores is 39.50 per cent.

Belgium.

The northern corner of the Lorraine Basin extends into Belgium but practically all the ore is now mined out and at present there is no production in

ANALYSES OF LORRAINE BASIN IRON ORES

Basin	District	Seam	Iron	Silica	Lime	Alumina	Phosphorous	Carbon Dioxide
Lorraine Annexee—	St. Michael	Grey	29-33	5–10	15–17	....	....	.....
	St. Michael	Brown	38–39	3–13	4–9	....	....	.....
	Bollingen	Grey	33.00	10.00	18.00	4.00	....	.....
	Bollingen	Red	35.00	7.00	12.00	....	....	.....
	Bollingen	Yellow	24.00	24.00	13.00	6.00	....	.....
	Aumetz-Arsweiler	Grey	32.00	9.00	15.00	....	....	.....
	Aumetz-Arsweiler	Red Sandy	36.00	26–27	2–3	....	....	.....
	Aumetz-Arsweiler	Red Cal.	34.00	8.00	15.00	....	....	.....
	Aumetz-Arsweiler	Yellow	33–36	9–10	10–12	....	....	.....
French Lorraine—	Alringen Valley	Grey	24–40	5–10	10–15	2.30	....	.....
	Alringen Valley	Black	36–37	14–15	6–7	....	....	.....
	Neuchef Mine	Grey	40.00	9.00	7.00	....	....	.....
	Neuchef Mine	Red Cal.	40.00	9.50	9.50	5.00	....	.....
	Neuchef Mine	Black	30.00	5–24	6.00	6.00	....	.....
	St. Paul Mine	Grey	37.40	6.80	9.20	....	....	.....
	St. Paul Mine	Yellow	36.00	8.40	12.00	....	....	.....
	St. Paul Mine	Brown	34.30	16.60	8.60	7.00	....	.....
	St. Paul Mine	Black	30.00	24.50	6.00	8.00	....	.....
	Joeuf	Grey	37.29	4.50	14.90	4.98	.62	.....
	Moutiers	Grey	38.24	6.56	11.30	....	....	.....
	Landres	Grey	39.20	6.20	9.05	6.10	1.05	18.70
	Sancy	Grey	39.90	6.00	11.00	4.90	.77	19.40
	Hussigny	Grey	35.50	17.20	7.40	8.30	....	15.50
	Godbrange	Grey	36.30	15.10	6.80	9.90	....	15.50
	Tiercelet	Grey	37.10	15.40	6.90	8.20	....	14.50
	Maringen Mine	Black	34.00	12–14	9–10	....	....	.....
	Nancy	Upper	36.00	11.00	7.00	....	....	.....
	Nancy	Middle	36.00	15.00	4.00	....	....	.....
	Nancy	Lower	33.00	17.00	4.00	....	....	.....
Luxemburg—	Dodelange	Upper	39.42	.....	11.23	5.05	.70	.....
	Dodelange	Lower	36.20	.....	13.13	4.69	.92	.....
	Rumelange	Yellow	36.00	.....	14.50	6.00	.82	.....
	Galgenberg	Red	39.47	.....	9.96	5.75	.68	.....
	Galgenberg	Grey	35.45	.....	17.20	3.30	.60	.....
	Galgenberg	Brown	45.00	.....	7.00	3.90	1.10	.....
	L'Alzette	Red	40.17	8.57	10.74	5.37	.80	8.43
	L'Alzette	Grey	29.82	4.84	22.10	2.91	.83	17.37
	Differdange	Yellow	34.81	.....	10.40	6.65	....	.....
	Differdange	Black	32.37	.....	11.00	4.88	....	.....

this district. The reserve is only estimated at 525,000 tons of ore very similar to the Luxemburg ores, but in all probability this district will never operate again.

Reserves.

The Lorraine Basin iron ore fields have been well explored and the estimates of the reserves are fairly accurate and reliable. The estimates made over the last ten years have been very close varying from 5,100,000,000 to 5,800,000,000 tons. Deducting the ore mined since these estimates it is safe to put the present tonnage at 5,600,000,000 tons of ore which will average 34 per cent of iron or about 1,900,000,000 tons of metallic iron.

IRON ORE RESERVES OF THE LORRAINE BASIN

District	Acres	Iron Ore Reserve	Production, 1913
French Lorraine—			
Briey	180,000	2,000,000,000	14,891,749
Longwy		300,000,000	2,737,159
Crusnes		500,000,000	....
Nancy		200,000,000	1,370,709
Lorraine Annexee—			
Aumetz-Arsweiler	106,000	1,425,000,000	21,136,000
Fentsch and Orne		485,000,000	
South of Orne		420,000,000	
Luxemburg	9,100	270,000,000	7,331,050
Belgium	750	525,000	....
Total	295,850	5,600,525,000	48,456,665

Assuming that the production of Lorraine iron ores increase 50 per cent over the 1913 maximum production, the above reserve will be sufficient to supply the requirements for from 75 to 100 years.

VARIOUS ESTIMATES OF THE LORRAINE IRON ORES

Estimated by	Year	Tonnage
Kohlmann	1911	5,191,000,000
E. C. Eckel	1914	5,600,000,000
A. H. Brooks	1919	5,805,519,000
Brooks and La Croix	1920	5,075,525,000
Max Roesler	1920	6,320,000,000*
Imperial Min. Res. Bureau	1922	5,600,525,000
Average		5,597,100,000

---

*Roessler also estimates the possible reserve at 1,500,000,000 tons.

The Lorraine iron ore fields compare very favorably with the other large known iron ore deposits and although the ore is low grade, the enormous tonnage balances it to a certain extent.

LARGE IRON ORE DEPOSITS OF THE WORLD

Country	Deposit	Reserve	Iron Content	Metallic Iron
Brazil	Minas Geraes	3,500,000,000	65.00%	2,275,000,000
Newfoundl'd.	Bell Island	4,000,000,000	50.00%	2,000,000,000
France	Lorraine	5,600,000,000	34.00%	1,900,000,000
United States	Superior	2,650,000,000	55.00%	1,457,500,000
Cuba	Oriente Prov.	3,000,000,000	45.00%	1,350,000,000

The above five deposits represent about 30 per cent of the worlds iron ore resources.

At the annual meeting of the stockholders of the Northern Engineering Works, manufacturers of electric traveling cranes, electric hoists and foundry equipment, Detroit, Mich., the following officers and directors were elected for the ensuing year: Henry W. Standart, president and treasurer; Harry C. Bulkley, vice president; Louis H. Olfs, secretary. The above, with W. Robertson, chief engineer of the company, and Joel H. Prescott, constitute the board of directors.

Combustion in O. H. Furnace with Special Reference to Automatic Control*

By K. HUESSENER†

IN the following presentation of data of combustion in the open hearth furnace and the advisability of automatic combustion control, the author finds himself much more severely handicapped by the lack of reliable test results than he had anticipated when he first undertook to write this paper.

In order thoroughly to investigate how the results of an open-hearth furnace are influenced by combustion, one would have to draw up a large number of heat-balance sheets, as Kinney and McDermott[1] have given for one heat in their extremely able paper "Open Hearth Efficiency," presented before the American Iron & Steel Institute on October 27, 1922. Instead of covering only one heat, however, such heat-balance sheets would have to embrace a large number of heats, and not only for one kind of fuel, but for all various fuels in customary use.

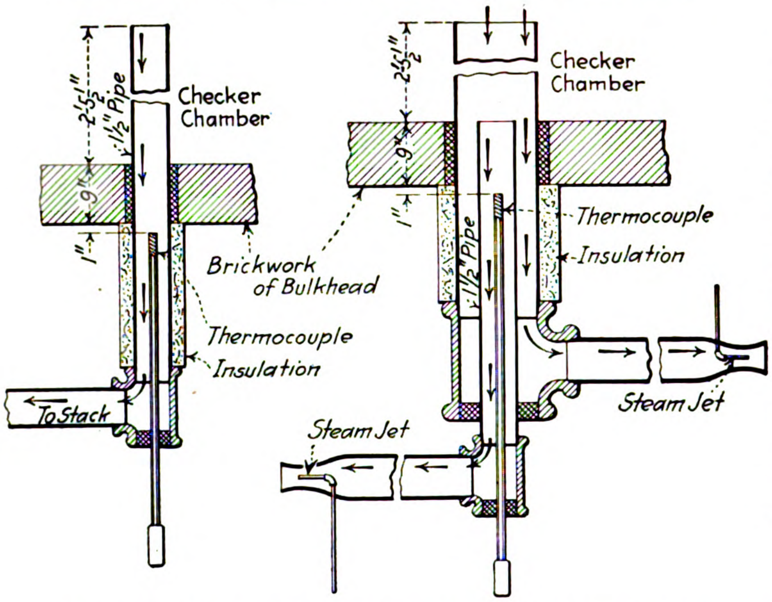

FIG. 1—(*Left*) *Arrangement of radiation with protected pyrometers as used.* FIG. 2—(*Right*) *Arrangement of radiation with protected pyrometers as recommeded.*

Use of Radiation-Protected Pyrometer.

Such tests necessitates extremely careful temperature readings, and here the first serious difficulty presents itself. Nearly all the temperature readings so far published have been taken with thermocouples for the lower ranges and with optical or radiation pyrometers for the higher ranges. This method of measuring reveals the temperature of the surrounding walls, or in the case of optical or radiation measurements, the temperature of that part of the opposing walls which has been focused by the instrument. The error in ascertaining the temperature of the gases entering or the waste gases leaving the checker chambers is probably not very large, as the flowing gases impart their temperature to the walls of the flues. On the other hand, the uptakes, where the preheat temperature of gas and air are usually measured, are under the influence of radiated heat from the port ends, and correct temperature readings can here be taken only by using a radiation-protected pyrometer of the aspirating type.

In the course of the author's tests on a 100-ton open-hearth furnace, using producer gas as fuel and equipped with Steinbart automatic control, it became necessary to measure the temperatures obtained in preheating the air. An aspirating pyrometer was used, as shown in Fig. 1[2]. The stack draft was utilized to pull the gases out of the checker chambers. As the couple of the pyrometer was completely protected against radiation, the temperature of the gases themselves was measured. The use of this type of pyrometer is strongly recommended; or better still, the construction shown in Fig. 2. As a result of these measurements, the author was truly surprised to find that the preheating temperatures of the air, which were measured only in this instance, proved to be very much lower than had been anticipated. The average of over 100 readings extending over 6 hr. amounted to 1360° F., the lowest average during a reversal being 1280° F. and the highest 1450° F. It should be mentioned that these measurements were taken very shortly after rebuilding.

Calculations of the Effect of Different Fuels and Different Amounts of Excess Air

A careful examination of the figures obtained did not reveal anything to indicate that they might not be correct. The author, therefore, decided to calculate theoretically what preheating temperature might be expected from a furnace of this type. The tables given in the appendix give a review of how the use of different fuels with different amounts of excess of air will influence the results from a 100-ton open-hearth furnace as it is at present usually built: Hearth surface, 580 sq. ft.; air-checker surface, 4175 sq. ft.; gas-checker surface, 2710 sq. ft.; or a relation between hearth surface to checker surface of 1:11.87.

Assumptions Made in Calculations—Before explaining the calculations and the conclusions drawn therefrom, it will be necessary to show why certain assumptions had to be made in order to be able to set up these tables. In view of the fact that the temperature at which the bath in an open-hearth furnace is active, is between 2800° and 2850° F. and further, in view of the fact that there must be a temperature drop if there is to be any heat transfer from the gases to the bath, we must assume that a minimum temperature of the gases of 3000° F. is necessary, if any work in the open-hearth furnace is to be done at all. The active heat in an open-hearth furnace can therefore only be that portion of the heat contained in the gases that carries the temperature beyond 3000° F.

---

*Presented before the American Institute of Mining and Metallurgical Engineers.

†Pres. American Heat Economy Bureau, Inc., Pittsburgh, Pa.

[1] C. L. Kinney, Jr., and G. R. M'Dermott: The Thermal Efficiency and Heat Balance of an Open-hearth Furnace. American Iron and Steel Institute Year Book (1922), 464.

[2] All Figures and Tables are given at the end of the text.

As the gases must remain active until after they actually have left the hearth room and entered the ports, we must assume that at the point of leaving the hearthroom, these gases still have a temperature of 3000° F. as otherwise, the outgoing end of the bath would always remain inactive, which, as is very well known, is certainly not the case. In following the course of the waste gases through the ports, uptakes and checker chambers to the reversing valve, we find a temperature drop from 3000° to about 1250° F. This exit temperature of the waste gases leaving the checker chambers, 1250° F., has also been assumed by the author to be a constant for the present type of furnace. The reason for this assumption is that in taking careful measurements, it was found that by doubling the flow of gas through an open-hearth furnace, the increase in exit temperatures was never more than 75° to 100° F. Therefore, for all practical purposes, it can be assumed that this temperature is actually fixed for the present type of checker chamber. The reason for this rather strange uniformity of exit temperatures is, in the author's opinion, to be found in the fact that today's type of check chambers does not by any means favor a uniform distribution either on the ingoing or on the outgoing end, so that large portions of the chambers are evidently always inactive. It appears that an increase in the quantity of gases reduces the inactive portions, and, conversely, a decrease of such quantity results in an increase of inactivity.

Accepting a fixed temperature of 3000° F. for the gases leaving the hearth and of 1250° F. for the gases leaving the checker chambers, we have a temperature drop of 1750° F. which must provide first, for the losses through radiation and conduction in the ports, uptakes and checkers, and, second, for the preheating heat of the air and the gas entering the checker chambers. In our calculations we encounter here the second difficulty which will probably lay us open to criticism, but, as certain assumptions will have to be made if the study of the combustion problems in an open-hearth furnace is to be carried any further, we believe that the method in which we provide for these losses will be at least approximately correct. In the paper by Kinney and McDermott[3] the temperature of the gases entering the checker chamber from the uptakes is given at approximately 2300° F. For the purpose of our calculation, we have accepted this figure as being approximately correct, and, therefore assume that all the losses, except the stack losses, are covered by the temperature drop from 3000° to 2300° F. That no serious error has been committed by this assumption, is, as will be seen later, evidenced by the fact that the calculated possible preheating temperatures approximate very fairly those ascertained by actual measurement. Another assumption which we had to make in order not to complicate matters too much, is that complete combustion of all the gases is always obtained before they leave the hearth. In other words, in our calculation we do not take care of any losses that might be due to portions of the gases not being completely burned over the hearth

The author feels justified in assuming such complete combustion, as it has been found that with automatic combustion control such losses are almost entirely eliminated. It is, of course, a fact that to burn all the CO gases generated by the reactions of the bath is often impossible because the necessary time to complete combustion is lacking before these gases reach the ports. The author believes that he has almost completely covered this source of error by crediting the process heat with the full amount of combustion heat derived from these gases in the form of exothermic heat. What actually happens is that these gases burn in the checker chambers, resulting in a consequent increase of the preheat temperature, and after all, the bulk of the heat thus lost is subsequently carried back to the bath.

As explained above, we have found that the exit temperature of any given checker chamber is not influenced by the quantity of waste gases passing through it. For this reason, it should be permissable to assume the same exit temperatures of all kinds of fuels. As a matter of fact, the author knows that for the 100-ton furnace under review, there are no worthwhile differences irrespective of whether the furnace is operated on straight coke-oven gas, tar, oil or producer gas.

Discussion of Tables 1 to 6.—In connection with the calculations, which are given in the Tables, it must be kept in mind that the sole purpose is to furnish comparatively correct figures. We believe that even if mistakes in our assumptions should have been made, these would materially change only the actual results obtained but not the relations between the results for the different fuels and for the different amounts of excess air.

Table 1 shows the weight of combustion air, the weight of the products of combustion and the heat content of these products of combustion at 3000° F. for different amounts of excess air from 0 to 40 per cent. These figures are interesting from several points of view. First of all, they show the tremendous weights of gases handled in the average 100-ton open-hearth furnace. Assuming that such a furnace makes 10 tons of steel per hour with a heat consumption of 6,000,000 B. t. u. latent heat, per ton of steel, and that the gas is completely burned with an excess of air of 30 per cent., then the weight of the gases passing through the furnace on an average hour, is in excess of 60,000 lbs. This will explain better than anything else the mechanical wear on the furnace ports and roof, which must eventially be worn down even if no damage by heat would be done to them at any time.

The heat content at 3000° F., given in Table 1, is the amount of heat that is available for providing for all radiation and conduction losses in the outgoing port, down-takes, checkers, and stack, the remainder being the amount of heat that will be carried back into the furnace as preheat of gas or air on the next reversal period. Table 1 shows that a temperature of 3000° F. cannot be obtained without preheating when using producer gas, whereas it is obtainable with natural gas and oil.

Table 2 shows how the heat content in the gases with different amounts of excess air is reduced by a temperature drop from 3000° to 2300° F. and from 2300° to 1250° F. As explained above, the drop from 3000° to 2300° F. given for each gas, in columns 2 and

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[3] C. L. Kinney and G. R. McDermott: Op. cit.

3, for instance, as assumed to take care of all the losses due to radiation and conduction, at the outgoing end of the furnace. The differences between the heat content in the 2300° F. columns and the 1250° F. columns, are the amounts of heat carried back into the furnace. This is all the heat actually available for preheating both gas and air.

Table 3, tabulates these amounts, which have been obtained by deducting the figures in the 1250° F. columns from the figures in the 2300° F. columns in Table 2.

Table 4a gives the heat available in the products of combustion above 3000° F. resulting from the latent heat of the fuel and the heat absorbed by the combustion air during preheating. The figures refer to natural gas, coke-oven gas and oil with different amounts of excess air from 0 to 40 per cent., for preheat temperatures from 32° to 2200° F. Taking into consideration the amounts of heat in the waste gases actually available for preheating, as given in Table 3, we find the values of B. t. u. available above 3000° F. as entered between the lines of Tables 4a, 4b, 4c and have marked same by running a line crosswise through the table, adding below the corresponding temperatures of preheat obtainable. We find that these temperatures do not materially vary, no matter whether the gas is burned with, or without an excess of air up to 40 per cent. As these possible preheat temperatures are still above the temperatures which we ascertained by actual measurements the conclusion is permitted that even by allowing a temperature drop from 3000° to 2300° F., all the losses between the port end and the reversing valves have not yet been properly covered. By increasing this allowance for losses, the possible preheat temperatures given in Table 4a would be reduced, but even then there would not be any change for the different amounts of excess air. The calculations so far appear to show that with coke-oven gas, natural gas and oil, when air alone is preheated and when the present customary type of open-hearth furnace is used, no higher preheat temperature than 1450° F. can reasonably be expected.

In Tables 4b and 4c, the same calculations are carried out for producer gas containing 150.3 and 132.5 B. t. u. (columns 5 and 6, Table 3.) In these two tables matters are a little complicated, as both gas and air are preheated. Our temperature measurements, previously mentioned, were taken on such a furnace and it is, therefore, fairly safe to assume that a preheating temperature for air about 1500° F. with a preheating temperature for gas of 1600° F. will usually be found in open-hearth furnaces of this type. If the preheating temperatures for air should be higher, the preheating temperature for gas would be lower, or vice versa. In either case the operation of the furnace would not be effected as the total amount of heat carried back into the hearth as preheat always remains the same.

Attention is next turned to the hearth itself to compare the amount of heat which are here available for the process of making steel, and which at the same time provide for the unavoidable losses through radiation, conduction and cooling water. These amounts of heat are shown in Tables 4a, 4b and 4c in the figures above the line drawn crosswise through these tables. Here we find for the first time how seriously an open-hearth furnace is affected by the excess of air with which the fuel is burned. This under the column of natural gas in Table 4a, the available heat that stays in the bath is 511,000 B. t. u. for every million B. t. u. of latent heat admitted, if the gas is burned with no excess of air at all. This available amount drops to 349,000 B. t. u. with an excess of air of 40 per cent. The comparative figures for coke-oven gas are 519,000 reduced to 369,000 B. t. u., and for oil 565,000 reduced to 413,000 B. t. u. It is surprising to find that the two kinds of producer gas, as fuel, appear to be superior to natural gas and coke-oven gas and only inferior to crude oil.

These figures of available heat in the hearth now put us in a position to calculate the heat consumption per ton of steel, assuming a certain duration of a heat. The available heat, as has already been stated above, has to cover, in addition to the process heat proper, the radiation, conduction, and cooling water losses. As we have no reliable figures regarding these losses for the 100-ton open-hearth furnace under review, we have accepted the figure given by Kinney and McDermott. In accordance with the balance sheet given in their paper, the losses of an 80-ton open-hearth furnace amounted to 88.1 million B. t. u. for a duration of heat of 9 hr., or 9.8 million B. t. u. per hour, which covers the radiation and cooling-water losses of the outgoing port. As we in the present instance are examining in a 100-ton furnace, the heat conditions of the hearth only and not including the outgoing port, we have assumed that this figure of 9.8 million B. t. u. lost per hour will be about correct for the larger furnace. Even if this were not so, it would only influence the actual figures which we hereafter calculate, but not their relative sizes. With regard to the process heat, we have also accepted the Kinney and McDermott figure, 1,060,000 B. t. u. per gross ton of steel made.

If we assume that 100 tons of steel are to be produced in 12 hr., then the process heat required for 100 tons of steel will be 106 million B. t. u. The radiation, conduction, and cooling-water losses will be 12 × 9.8 million B. t. u., or approximately 118 million B. t. u. In other words, for every ton of steel produced, 2,240,000 B. t. u. must enter the bath and supply the radiation, conduction, and cooling-water losses. By referring to Table 4a, we find that for natural gas burned with no excess of air, the available heat in the hearth is 511,000 B. t. u. for every million B. t. u. of latent heat admitted, so that it will take $\frac{2{,}240{,}000 \text{ B.t.u.}}{.511}$ = 4.4 millions B. t. u. latent heat in the fuel in order to make one ton of steel, provided that it takes 12 hr. to finish the heat. If the heat is finished in 10 instead of 12 hr., the process heat will still have remained 106 millions B. t. u. but the radiation, conduction, and cooling-water losses will be cut down to 10×9.8 millions B. t. u. = 98 millions B. t. u., so that the total heat requirements per ton of steel would only have been 2.04 millions B. t. u. The same amount of 511,000 B. t. u. being available in the hearth, it will be possible to make one ton of steel with $\frac{2.04}{.511}$ = 4 millions B. t. u. latent heat. In exactly the same manner the required amounts of latent heat for excesses of air from 0 to 40 per cent. have been calculated, and for durations of heat of 12, and 8 hr. for the five kinds of fuels (Table 5.

Table - 1.

Weight Of Combustion Air, Products Of Combustion And Heat Content Of Products At 3000 °F.

From The Combustion Of Various Fuels. Heat Content Measured Above 32°F.
Each Containing One Million B.T.U. Latent Heat.

When Combustion Air Is In Excess %	987 Cu.Ft. Of Natural Gas. @ 1012 B.T.U. /Cu.Ft			1890 Cu. Ft. Of Coke Oven Gas @ 529 B.T.U./Cu.Ft.			52.2 Lbs. Of Crude Oil @ 19210 B.T.U./Lb. (7.09 Gallons @ 141000 B.T.U.)			6660 Cu.Ft. Of Dry Prod. Gas @ 150.3 B.T.U. /Cu.Ft. (From 93.7 Lbs Of Coal @ 13500 B.T.U.)			7550 Cu.Ft. Of Dry Prod. Gas @ 132.5 B.T.U. /Cu.Ft. (From 102.7 Lbs. Of Coal @ 13500 B.T.U.)		
	Weight Of Air Lbs.	Weight Of Products Lbs.	Heat Content Of Products At 3000 °F. B.T.U.	Weight Of Air Lbs.	Weight Of Products Lbs.	Heat Content Of Products At 3000 °F. B.T.U.	Weight Of Air Lbs.	Weight Of Products Lbs.	Heat Content Of Products At 3000 °F. B.T.U.	Weight Of Air Lbs.	Weight Of Products Lbs.	Heat Content Of Products At 3000 °F. B.T.U.	Weight Of Air Lbs.	Weight Of Products Lbs.	Heat Content Of Products At 3000 °F. B.T.U.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16.
0	799	843	769,000	741	794	739,000	755	807	693,000	652	1094	947,000	640	1153	996,000
5	839	883	801,000	778	831	768,000	793	845	723,000	688	1127	973,000	672	1185	1,021,000
10	880	923	832,000	815	868	798,000	830	882	753,000	717	1159	999,000	704	1217	1,047,000
15	920	963	864,000	852	905	827,000	868	920	783,000	750	1192	1,024,000	736	1249	1,072,000
20	960	1003	896,000	889	942	856,000	906	958	812,000	782	1224	1,050,000	768	1281	1,097,000
25	1000	1043	927,000	926	979	885,000	943	995	842,000	815	1257	1,076,000	800	1313	1,123,000
30	1040	1083	959,000	963	1016	915,000	981	1033	872,000	847	1289	1,102,000	832	1345	1,148,000
35	1080	1123	991,000	1000	1053	944,000	1019	1071	902,000	880	1322	1,127,000	864	1377	1,173,000
40	1120	1163	1,022,000	1037	1090	973,000.	1057	1109	931,000	913	1355	1,153,000	896	1409	1,199,000

Table - 2.

Heat Content Of Products Of Combustion.

At Various Temperatures. Heat Content Measured Above 32°F.
From Various Fuels, Each Containing One Million B.T.U. Latent Heat.

When Combustion Air Is In Excess %	From 987 Cu.Ft. Of Natural Gas @ 1012 B.T.U. / Cu.Ft.			From 1890 Cu.Ft. Of Coke Oven Gas @ 529 B.T.U. /Cu.Ft.			From 52.2 Lbs. Of Crude Oil. @ 19210 B.T.U. /Lb. (7.09 Gallons @ 141,000 B.T.U.)			From 6660 Cu.Ft. Of Dry Prod. Gas @ 150.3 B.T.U. / Cu.Ft. (From 93.7 Lbs. Coal @ 13500 B.T.U.)			From 7550 Cu.Ft. Dry Prod. Gas @ 132.5 B.T.U. / Cu.Ft. (From 102.7 Lbs. Coal @ 13500 B.T.U.)		
	B.T.U. In Products Of Combustion At			B.T.U. In Prod. Of Combustion At			B.T.U. In Prod. Of Combustion At			B.T.U. In Prod. Of Combustion At			B.T.U. In Prod. Of Combustion At		
	3000°	2300°	1250°	3000°	2300°	1250°	3000°	2300°	1250°	3000°	2300°	1250°	3000°	2300°	1250°
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	769,000	572,000	292,000	739,000	538,000	280,000	693,000	528,000	270,000	947,000	708,000	362,000	996,000	739,000	378,000
5	801,000	596,000	304,000	768,000	560,000	291,000	723,000	550,000	282,000	973,000	727,000	372,000	1,021,000	758,000	388,000
10	832,000	619,000	317,000	798,000	582,000	303,000	753,000	572,000	293,000	999,000	747,000	382,000	1,047,000	777,000	398,000
15	864,000	643,000	329,000	827,000	604,000	314,000	783,000	595,000	305,000	1,024,000	766,000	392,000	1,072,000	796,000	407,000
20	896,000	667,000	341,000	856,000	625,000	325,000	812,000	617,000	316,000	1,050,000	785,000	402,000	1,097,000	815,000	417,000
25	927,000	690,000	353,000	885,000	647,000	337,000	842,000	639,000	328,000	1,076,000	804,000	412,000	1,123,000	833,000	427,000
30	959,000	714,000	366,000	915,000	669,000	348,000	872,000	662,000	339,000	1,102,000	823,000	422,000	1,148,000	852,000	437,000
35	991,000	738,000	378,000	944,000	691,000	359,000	902,000	684,000	351,000	1,127,000	843,000	432,000	1,173,000	871,000	447,000
40	1,022,000	761,000	390,000	973,000	713,000	371,000	931,000	706,000	362,000	1,153,000	862,000	442,000	1,199,000	890,000	456,000

Table - 3.

Heat Available For Preheating Combustion Air And Fuel.

Derived From The Combustion Of Various Fuels Referred To 1-Million B.T.U. Latent Heat.
Admitted For Combustion For A Temp. Drop From 2300 °F. To 1250 °F.

Excess Of Air. %	987 Cu.Ft. Of Natural Gas @ 1012 B.T.U. /Cu.Ft.	1890 Cu.Ft. Of Coke Gas @ 529 B.T.U. /Cu.Ft.	52.2 Lbs. Of Crude Oil. @ 19210 B.T.U. /Lb.	6660 Cu.Ft. Of Dry Prod. Gas @ 150.3 B.T.U. /Cu.Ft.	7550 Cu.Ft. Of Dry Prod. Gas. @ 132.5 B.T.U. /Cu.Ft.
1.	2.	3.	4.	5.	6.
0	280,000	258,000	258,000	346,000	361,000
5	292,000	269,000	268,000	355,000	370,000
10	302,000	279,000	279,000	365,000	379,000
15	314,000	290,000	290,000	374,000	389,000
20	326,000	300,000	301,000	383,000	398,000
25	337,000	310,000	311,000	392,000	406,000
30	348,000	321,000	323,000	401,000	415,000
35	360,000	332,000	333,000	411,000	424,000
40	371,000	342,000	344,000	420,000	434,000

Looking over these figures, we find that crude oil is approximately the best kind of fuel, by 10 per cent. Natural gas shows the greatest drop in efficiency with increased excess of air, whereas producer gas is about equal to coke-oven gas. It is very interesting to note how very little the results are influenced by the quality of the producer gas, but one must not forget that after all the gas with 150 B. t. u. means a considerably larger producer efficiency than the gas of 132 B. t. u. and will, therefore, reduce the pounds of coal per ton of steel. The figures given in Table 5 for producer gas are in millions B. t. u. latent heat in the gas and not in the coal. The gas of 150.3 B. t. u. would correspond to a producer efficiency (latent heat in gas: latent heat in coal) of 79 per cent., and the gas of 132.5 B. t. u. to an efficiency of 72 per cent. We have entered in brackets, under these figures of required latent heat in the gas, the pounds of coal of 13,500 B. t. u. per ton of steel at these producer efficiencies. In the same way, we have entered the amounts of fuel required for natural gas, coke-oven gas and oil.

TABLE 4-A.

B.T.U. AVAILABLE IN BATH. (ABOVE 3000°F).

FOR 1-MILLION B.T.U. LATENT HEAT ADMITTED
WITH VARYING EXCESS AIR AND AT VARYING TEMP. OF THE PREHEATED AIR
(THE FUEL BEING COLD.)

COMBUSTION AIR BEING PREHEATED TO --- °F.	FROM 987 CU.FT. OF COLD NAT. GAS.				FROM 1890 CU.FT. OF COLD COKE OVEN GAS				FROM 52.2 LBS. OF COLD CRUDE OIL.			
	WHEN COMBUSTION AIR IS IN EXCESS.				WHEN COMBUSTION AIR IS IN EXCESS.				WHEN COMBUSTION AIR IS IN EXCESS.			
	0%	10%	20%	40%	0%	10%	20%	40%	0%	10%	20%	40%
NO PREHEAT. 32°	231,000	168,000	104,000	NONE.	261,000	202,000	144,000	27,000	307,000	247,000	188,000	69,000
1000°F.	424,000	381,000	336,000	249,000	439,000	398,000	358,000	277,000	489,000	447,000	406,000	324,000
	511,000 (1430°)	470,000 (1390°)	430,000 (1380°)	349,000 (1360°)	519,000 (1420°)	481,000 (1390°)	444,000 (1380°)	369,000 (1340°)	565,000 (1390°)	526,000 (1370°)	489,000 (1360°)	413,000 (1330°)
1600°F.	550,000	521,000	488,000	426,000	556,000	527,000	499,000	441,000	608,000	578,000	550,000	491,000.
1900°F.	613,000	590,000	564,000	515,000	615,000	592,000	569,000	524,000	668,000	644,000	621,000	574,000
2200°F.	680,000	665,000	645,000	609,000	677,000	660,000	644,000	610,000	731,000	714,000	697,000	663,000

TABLE 4-B.

B.T.U. AVAILABLE IN BATH (ABOVE 3000°F).

FOR 1-MILLION B.T.U. LATENT HEAT IN DRY PRODUCER GAS OF 1000°F. ENTERING CHECKER CHAMBERS.
WITH VARYING EXCESSES OF AIR, PREHEATING AIR AND FUEL TO VARIOUS TEMPERATURES.

RICH PRODUCER GAS. LATENT HEAT OF 6660 CU.FT. = 1,000,000 B.T.U. SENSIBLE HEAT OF 6660 CU FT (1000°F.) = 128,000 B.T.U.												
COMBUSTION AIR PREHEATED TO---°F.	PRODUCER GAS TEMPERATURE 1000°F (NOT PREHEATED)				PRODUCER GAS TEMPERATURE 1600°F. (PREHEATED BY 600°F)				PRODUCER GAS TEMPERATURE 2200°F. (PREHEATED BY 1200°F)			
	COMBUSTION AIR IN EXCESS.				COMBUSTION AIR IN EXCESS				COMBUSTION AIR IN EXCESS.			
	0%	10%	20%	40%	0%	10%	20%	40%	0%	10%	20%	40%
NO PREHEAT 32°	181,000	119,000	78,000	25,000	267,000	215,000	164,000	61,000	355,000	303,000	252,000	149,000
1000°F.	338,000	302,000	266,000	195,000	424,000	388,000 494,000 (1570°)	352,000 461,000 (1530°)	281,000 395,000 (1480°)	512,000 527,000 (1080°)	476,000 494,000 (1040°)	440,000 461,000 (1100°)	369,000 395,000 (1110°)
1600°F.	441,000	415,000	390,000	339,000 395,000 (1830°)	527,000 (1600°)	501,000	476,000	425,000	615,000	589,000	564,000	513,000
1900°F.	493,000 527,000 (2090°)	472,000 494,000 (2010°)	452,000 461,000 (1940°)	411,000	579,000	558,000	538,000	497,000	667,000	646,000	626,000	585,000
2200°F.	547,000	532,000	517,000	488,000	633,000	618,000	603,000	574,000	721,000	706,000	691,000	662,000.

Table 6 shows the average flow of fuel per hour necessary to obtain the results given in Table 5, assuming that the fuel could be admitted to the furnace in uniform quantities every hour. Actually, of course, the flow during the melting period is very much larger than during the refining period. This table shows very clearly that to get good fuel economy in on open-hearth furnace, two things are absolutely essential: One is to regulate combustion by keeping the excess of air as near as possible to zero; the other is to burn as much fuel as possible in a given time. A comparison of Tables 5 and 6 shows that by increasing the flow of natural gas from an average of 36,000 cu. ft. per hour to an average of 44,400 per hour (always provided that all the gas is being completely burned before it leaves the hearth, and with no excess of air, we reduce the time of the heat from 12 to 8 hr (Table 6), and the heat consumption from 4.4 millions to 3.6 millions B. t. u., latent heat per ton of steel (Table 5). The need for burning increased quantities of gas per hour demands the installation of forced-draft fans capable of supplying enough combustion air at all times and of induced-draft fans where the available chimney draft is not enough to handle the increased quantities of products of combustion. In this latter respect, changes will usually not be necessary; if the excess of air is cut down, the amount of waste gas, even from larger consumption of gas, will usually not be larger. For instance, Table 6 shows that by cutting the excess of air down from 20 to 10 per cent., for a furnace using natural gas, the same rate of flow

TABLE 4-C.

B.T.U. AVAILABLE IN BATH (ABOVE 3000°F.)

FOR 1-MILLION B.T.U. LATENT HEAT IN DRY PRODUCER GAS OF 1000°F. ENTERING CHECKER CHAMBERS.
WITH VARYING EXCESSES OF AIR, PREHEATING AIR AND FUEL TO VARIOUS TEMPERATURES.

POOR PRODUCER GAS. LATENT HEAT OF 7550 CU.FT. = 1,000,000 B.T.U. SENSIBLE HEAT OF 7550 CU.FT. (1000°F.) = 146,000 B.T.U.

COMBUSTION AIR PREHEATED TO --- °F.	PRODUCER GAS TEMPERATURE 1000°F. (NOT PREHEATED)				PRODUCER GAS TEMPERATURE 1600°F. (PREHEATED BY 600°F.)				PRODUCER GAS TEMPERATURE 2200°F. (PREHEATED BY 1200°F)			
	COMBUSTION AIR IN EXCESS.				COMBUSTION AIR IN EXCESS.				COMBUSTION AIR IN EXCESS.			
	0%	10%	20%	40%	0%	10%	20%	40%	0%	10%	20%	40%
NO PREHEAT 32°	150,000	99,000	49,000	NONE.	255,000	204,000	154,000	52,000	349,000	298,000	248,000	146,000
1000°F.	304,000	269,000	234,000	163,000.	409,000	374,000 478,000 (1320°)	339,000 447,000 (1540°)	268,000 381,000 (1480°)	503,000 511,000 (1050°)	468,000 478,000 (1060°)	433,000 447,000 (1070°)	362,000 381,000 (1080°)
1600°F.	405,000	380,000	356,000	304,000	511,000	485,000	461,000	409,000	604,000	579,000	555,000	503,000
1900°F.	456,000	435,000 478,000 (2120°)	416,000 447,000 (2030°)	375,000 381,000 (1960°)	561,000	540,000	521,000	480,000	655,000	634,000	615,000	574,000
2200°F.	510,000 511,000 (2210°)	495,000	481,000	450,000	615,000	600,000	586,000	555,000	709,000	694,000	680,000	649,000

TABLE-5.

LATENT HEAT IN FUEL TO BE SUPPLIED FOR COMBUSTION TO A 100 t. OPENHEARTH FURNACE
FOR MAKING 1-TON OF STEEL.
FOR VARYING DURATION OF A HEAT AND VARYING EXCESS OF THE COMBUSTION AIR
CONSIDERING THE ACTUAL HEAT LOSSES OF THE PROCESS AND ACTUAL WORKING CONDITIONS REQUIRED. (ABOVE 3000°F.).

WHEN COMBUSTION AIR IS IN EXCESS %	MILLIONS B.T.U. IN NAT. GAS. (CU.FT. OF GAS @ 1012 B.T.U.)			MILLIONS B.T.U. IN COKE GAS. (CU.FT. OF GAS @ 529 B.T.U.)			MILLIONS B.T.U. IN CRUDE OIL. (GALLONS @ 141,000 B.T.U.)			MILLIONS B.T.U. IN RICH PROD. GAS (LBS. OF COAL @ 13500 B.T.U.)			MILLIONS B.T.U. IN POOR PROD. GAS (LBS. OF COAL @ 13500 B.T.U.)		
	DURATION OF HEAT			DURATION OF HEAT			DURATION OF HEAT.			DURATION OF HEAT			DURATION OF HEAT.		
	12 HRS.	10 HRS.	8 HRS.	12 HRS.	10 HRS	8 HRS.	12 HRS.	10 HRS.	8 HRS.	12 HRS	10 HRS.	8 HRS.	12 HRS	10 HRS	8 HRS.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	4.4 (4350)	4.0 (3960)	3.6 (3570)	4.35 (8150)	3.95 (7410)	3.55 (6680)	4.0 (28.2)	3.65 (25.7)	3.25 (23.1)	4.3 (400)	3.9 (365)	3.5 (330)	4.4 (450)	4.0 (410)	3.6 (370)
10	4.8 (4710)	4.35 (4290)	3.9 (3870)	4.7 (8770)	4.25 (7990)	3.85 (7210)	4.25 (30.2)	3.9 (27.5)	3.5 (24.8)	4.55 (425)	4.15 (390)	3.75 (350)	4.7 (480)	4.3 (440)	3.85 (395)
20	5.2 (5150)	4.75 (4690)	4.3 (4230)	5.05 (9530)	4.6 (8680)	4.15 (7820)	4.6 (32.5)	4.2 (29.6)	3.75 (26.7)	4.9 (460)	4.45 (415)	4.0 (375)	5.0 (510)	4.6 (470)	4.1 (420)
40	6.4 (6320)	5.85 (5760)	5.25 (5190)	6.1 (1150)	5.5 (1040)	5.0 (9430)	5.45 (38.5)	4.95 (35.1)	4.45 (31.6)	5.7 (535)	5.2 (485)	4.65 (435)	5.9 (605)	5.4 (555)	4.85 (495)

TABLE-6.

AVERAGE RATE OF FLOW OF FUEL TO BE COMPLETELY BURNED IN A 100 t. OPEN HEARTH FURNACE.
FOR MAKING A 100 t. HEAT
FOR VARYING DURATION OF A HEAT AND AT VARYING EXCESS OF THE COMBUSTION AIR.
CONSIDERING THE ACTUAL HEAT LOSSES OF THE PROCESS AND ACTUAL WORKING CONDITIONS REQUIRED (ABOVE 3000°F.).

WHEN COMBUSTION AIR IS IN EXCESS %	NATURAL GAS IN CU.FT./HR.			COKE GAS IN CU.FT./HR.			OIL IN GALLONS/HR. 1-GAL. = 7.34 LBS. = 141,000 B.T.U.			RICH PROD. GAS IN CU.FT./HR. (IN LBS. OF COAL/HR.)			POOR PROD. GAS IN CU.FT./HR. (IN LBS. OF COAL/HR.)		
	DURATION OF HEAT			DURATION OF HEAT			DURATION OF HEAT.			DURATION OF HEAT			DURATION OF HEAT.		
	12 HRS.	10 HRS.	8 HRS.	12 HRS.	10 HRS.	8 HRS.	12 HRS.	10 HRS.	8 HRS.	12 HRS.	10 HRS.	8 HRS.	12 HRS	10 HRS	8 HRS.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
C	36,000	40,000	44,400	66,000	75,000	84,000	236	259	288	238,000 (3330)	260,000 (3650)	291,000 (4120)	277,000 (3750)	302,000 (4100)	339,000 (4,500)
10	40,000	43,000	48,100	74,000	80,000	89,000	251	277	310	252,000 (3540)	276,000 (3900)	312,000 (4370)	295,000 (4000)	324,000 (4400)	363,000 (4940)
20	43,000	47,000	53,100	80,000	87,000	98,000	272	298	332	272,000 (3830)	296,000 (4150)	332,000 (4680)	314,000 (4240)	347,000 (4700)	386,000 (5250)
40	53,000	58,000	64,800	96,000	104,000	129,000	322	351	394	316,000 (4460)	346,000 (4850)	387,000 (5430)	371,000 (5040	407,000 (5550)	457,000 (6180)

of gas will result in reducing the duration of a heat by 2 hr. and the fuel consumption from 5150 to 4240 cu. ft. of gas per ton of steel. The same condition holds for coke-oven gas.

It would be hasty to conclude that fuels can be positively compared to each other on the strength of Tables 5 and 6, because of the difficulty of obtaining complete combustion. Table 5 shows that with an excess of air of 40 per cent in a 12-hr. duration of heat, only 38.5 gal. of oil should be used per ton of steel, and with the same excess of air for an 8-hr. heat, this consumption would only be 31.6 gal. There are, without any doubt, many furnaces that will complete 100-ton heats on oil in 8 hr., but their fuel consumption will usually be above 36 gal. per ton of steel and often even considerably more. The reason, in the author's opinion, lies in the difficulty of obtaining complete combustion of the oil. It is extremely hard, if not impossible, to atomize the oil properly with the combustion arrangement as used at present. With producer gas, the difficulty in obtaining the results as shown in Table 5 lies probably in the very large quantities of gas which have to be handled, and in the fact that the checker chambers are quickly sooted up, so that even if enough air can be forced into the furnace for combustion, there is always a certain amount of difficulty with the draft. Besides, it should be mentioned here, all our figures have been based on dry producer gas, which in actual practice is, of course, not available. The moisture in the gas will naturally reduce the temperatures obtainable over the hearth and, therefore, the heat available above 3000° is in practice smaller than the figures shown in Tables 4b and 4c.

The results for coke-oven gas in Table 5 have actually been obtained for a considerable period by the help of automatically controlled combustion. This fact alone would tend to show that the calculations submitted in this paper are, to a certain extent, borne out by facts. The author's experience with natural gas is not sufficient, so far, to allow him to venture any opinion, although there does not appear to be any reason why the figures calculated in Table 5 should not at least be approached

Operation of a Furnace with Combustion Control.

One of the purposes of combustion control is to make the furnace independent of the chimney effect of the checker chambers for the supply of air. For this purpose, an induced-draft fan is installed usually in the passage between the two regenerator chambers as shown in Fig. 3. The air is taken into the fan through an intake box carrying an orifice plate. The quantity of air entering the fan is thus measured by the draft set up in this intake box, which represents the drop from atmospheric pressure through the orifice. From the fan, the air is conveyed to an auxiliary air-reversing valve, which consists of a steel-plate box equipped with cast-iron much-room valves. These latter are tied in with the operating mechanism of the main reversing valve, so that their reversals are automatic, together with the reversals of the furnace.

Fig. 3 shows an open-hearth furnace which is equipped for coke-oven or natural and producer gas. If the furnace is fired with either coke-oven or natural gas, the quantity of gas is measured by an orifice plate in the main gas-supply pipe ahead of the reversing valves. For the purpose of having the quantity of air that enters the regenerators automatically follow the quantities of gas passing through the orifice plate, a Huessener combustion regulator is used.

(To be continued)

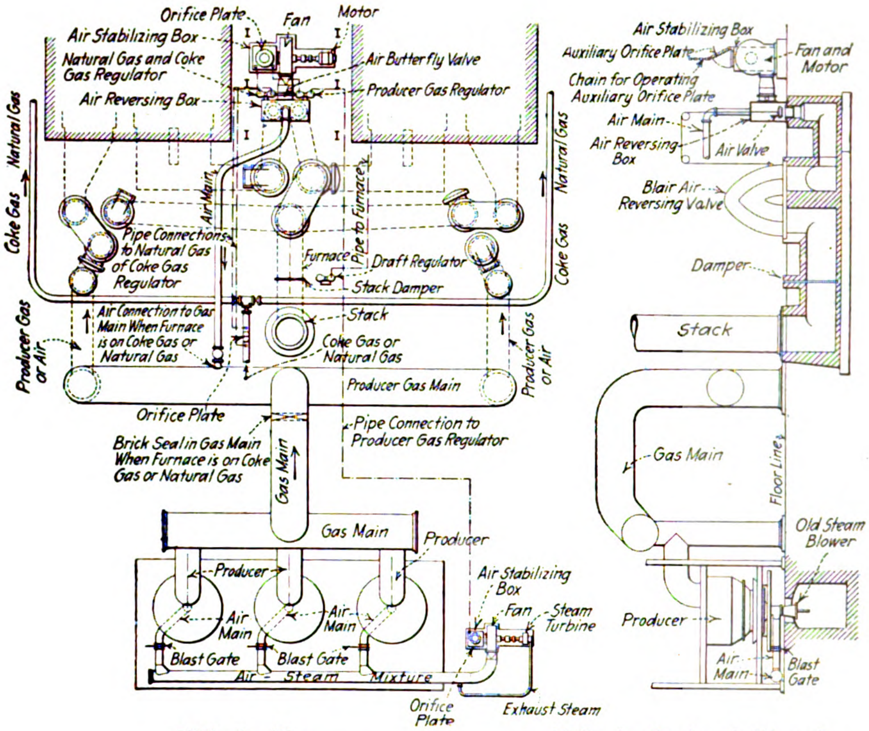

FIG. 3—*Plan.* FIG. 4—*Sectional Elevation.*

General layout of installation with furnace equipped for firing with natural gas, coke-oven gas or producer gas.

THE SAFETY CRUSADE

Dependable Gas Valves

Carnegie Steel Engineer Solves the Problem of Practical Spectacle Valve

By F. J. CROLIUS

THERE is no single thing of greater importance around a blast furnace plant than the valves in the main gas lines. While this fact is true and is an acknowledged condition in the minds of all blast furnace operators and engineers, it is also equally true that these particular valves have been anything but satisfactory as usually designed and installed.

The peculiarities surrounding such a valve operation are such that practice demands a spectacle type. The mains are larger, often 10 ft. in diameter; the gas is hot, up to 600 deg., so that refractory linings are often necessary; the gas is dirty, that is, contains dust and moisture, which depositing interferes with clear valve surfaces for seating; the gas is extremely noxious, demanding a tight shut-off when repair work is to be undertaken; the valves are more seldom than not located high up in the air, frequently 75 ft. above the ground; the valves are usually chain operated by means of a sprocket, which in the case of larger valves requires considerable man-power to move; such valves are infrequently operated, but often in sudden emergencies when quick movement is essential.

It is not surprising that Carnegie Steel Company engineers have finally hit upon a very practical adaptation of the Spectacle Valve. Operating more blast furnace units than any other organization in the world, and with more miles of large diameter gas mains than any other—the valve situation has always been an interesting one.

It remained for W. C. McGee, Chief Engineer of the Mingo Junction plant of the Carnegie Steel Company to develop and put into service the valve shown in Figs. 1-4. After more than a year's operation no question has been raised as to its complete effectiveness; it does all that a valve should do, it opens easily and closes tight.

From the explanation accompanying Fig. 2 and 4, it will be seen that thermal expansion of a metal tube is the force relied upon to allow free movement of the valve plate. Nothing could be simpler, more effective nor more obvious; the first reaction when analyzed by another engineer is "Why Not, why didn't we do it that way ourselves?"

Why Not? Expansion tubes have been used successfully to control a number of the most vital and delicate operations in the steel industry for years, and the forces at command are definite and positive. A certain difference in temperature must result in a certain expansion or contraction, and when the thermal unit is physically tied to something movable, that something must move—so far.

In the case of the McGee valve, the something is the pipe flanges; and the difference in temperature is caused by changing a flow of steam in the expansion element to a flow of cold water and vice versa, 270-300 deg. difference.

With the flange movement accomplished by the mere turning of a small valve in the steam or water line, (which valves may be conveniently located near the ground level) the opening and closing of the larger Spectacle valve can be quickly done by a single man's pull on the chain. To further reduce the man-power demand, the actual pull is transmitted through a bronze worm and gear.

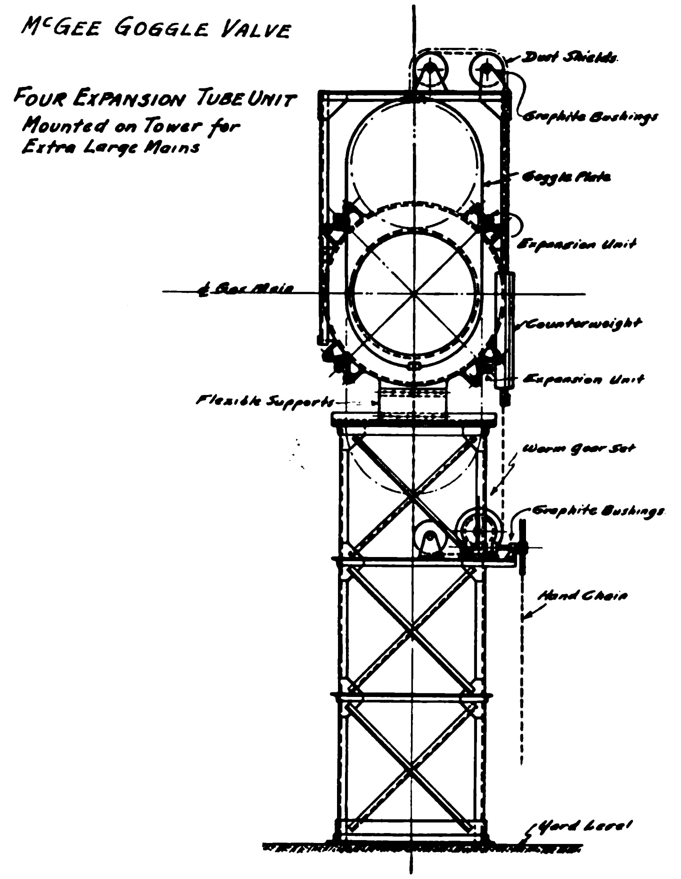

FIG. 1—*Shows an installation of this novel valve mounted upon structural support to meet the usual operating condition found in blast-furnace gas mains.*

The safety and security of such a freely moving valve together with the positiveness of its seating

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Drawings furnished by William Bailey Company, Pittsburgh, distributors.

when the expansion power has been released cannot be emphasized too strongly. One experience at a blast furnace when immediate valve closings meant life or death to a number of workmen, with further hazard to a repair crew is quite enough to convince the most skeptic of the value of positive valves.

This McGee valve which can be opened and closed in two to three precious minutes by a single man standing on the ground, deserves a welcome not usually accorded every worthy improvement in blast furnace practice.

Details of Construction and Operation.

Goggle Valve consists of two annular steel casting flanges riveted to plate shell of blast furnace gas main or plate main for conveying exhaust steam or any gases, the contact edges of these flanges being spaced a sufficient distance apart to receive a copper bearing steel goggle plate between them, length of goggle plate being sufficient to contain eye and blank, also stop lugs. Goggle Plate is plain mill plate of copper steel. Eye in goggle plate is approximately one-half the area of inside diameter of main; for instance, and 8 ft. 0 in. main with 3 in. lining would give a 5 ft. 6 in. opening in goggle plate. On small sizes, brick lining is tapered to goggle plate opening diameters; on large sizes, an interior plate forms Venturi effect.

To clamp goggle plate gas tight and to separate main sufficiently to move goggle plate to open or closed position, expansion tubes are used, connected to lugs on annular flanges through a crosshead on extreme ends and pull rods. On moderate sizes, two expansion tubes are used and on large sizes four expansion tubes, the four tubes being spaced as nearly 90 deg. as possible. Operation is by steam, hot blast or low voltage, alternating current, heating of expansion tubes, the expansion or contraction of steel tubes amounting to .000006 in. per deg. F. per unit of length. Assuming summer condition to be 100 deg. air temperature, plus 50 deg. transmitted through air from hot gas in main to expansion tubes, the base temperature would be equivalent to 150 deg.

Expansion tubes and connecting rods and lugs, etc., are designed strong enough to exert a pressure of 1,000 lbs. per linear inch of contact edge of annular steel casting flanges on goggle plate, which is amply sufficient to overcome any possible warping in goggle

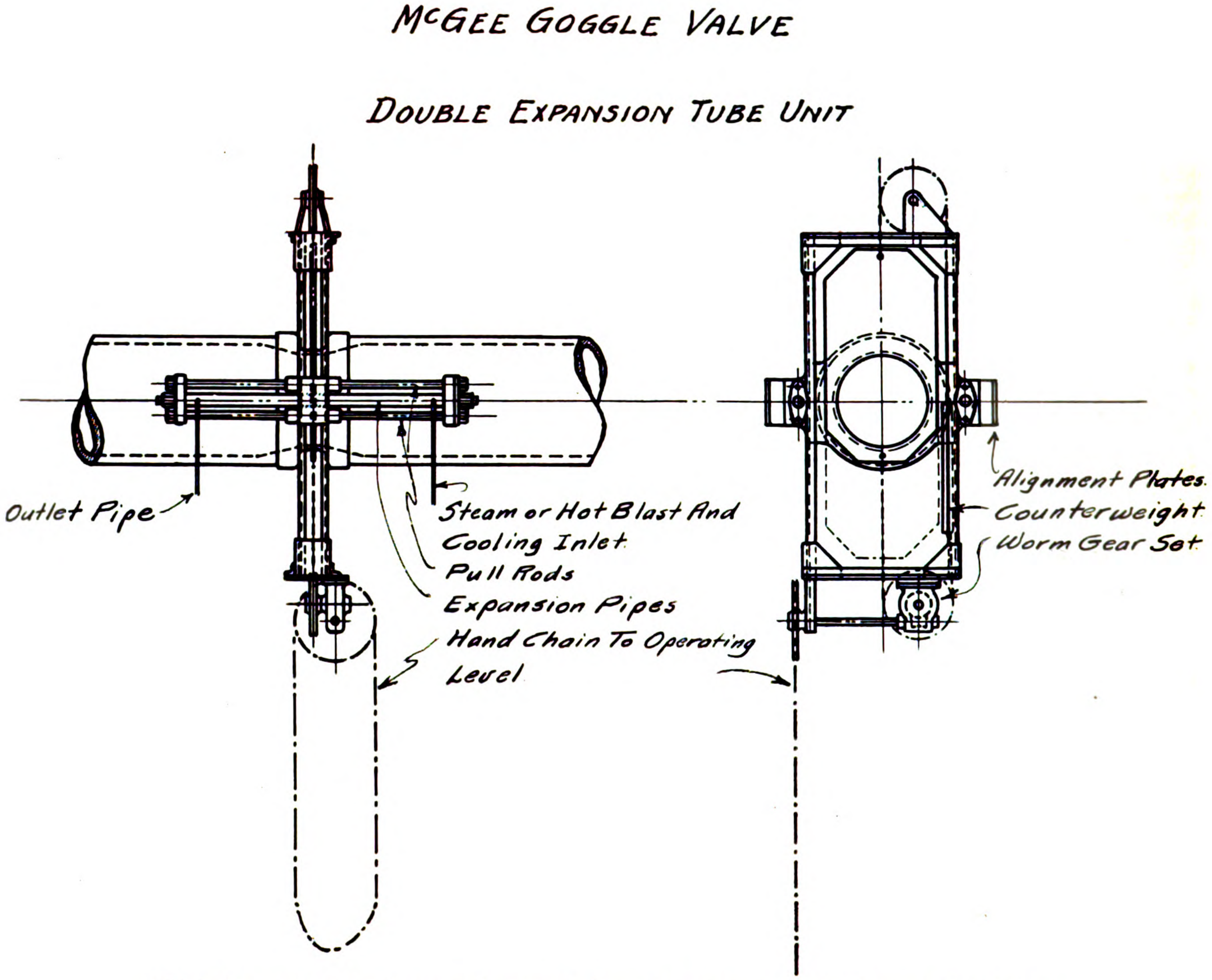

FIG. 2—*To meet the requirements of extremely large diameter gas lines, double expansion tube units have been designed. Note the assembly details.*

Temperatures of Heating Medium	Base Temperature	Available for Expansion	Expansion per Foot Length	Length of Expansion Tubes for ⅛ in. Movement
Steam, at 50 lb. gauge—297 deg..........	150 deg.	147 deg.	.0106 in.	11.7 ft.
Steam, at 100 lb. gauge—337 deg..........	150 deg.	187 deg.	.0135 in.	9.3 ft.
Steam, at 150 lb. gauge—365 deg..........	150 deg.	215 deg.	.0155 in.	8.1 ft.
Steam, at 200 lb. gauge—387 deg..........	150 deg.	237 deg.	.017 in.	7.4 ft.
Hot Blast, 600-900 deg..................	150 deg.	450 deg.-750 deg.	.033 in.-.054 in.	3.8 ft. to 2.3 ft.

plate and seal contact edges gas tight, also to force mains apart for movement of goggle plate in opening or closing valve.

For goggle plate sliding vertically, a counterweight of equal weight is provided, sliding within angle frame, and connected from top of goggle plate with chain over graphite-bushed top sheave to top of counterweight; and from bottom of counterweight with chain around operating sheave mounted on worm gear shaft and up to bottom of goggle plate, giving positive movement in either direction. Operating equipment for moving goggle plate is worm gear set in oil-tight graphite bushing to hand chain wheel, from which hand chain extends to ground or convenient operating location. Worm gear set and its equipment is designed for 1,500 ft. pound torque, or three men pulling on hand chain. Only one man is required.

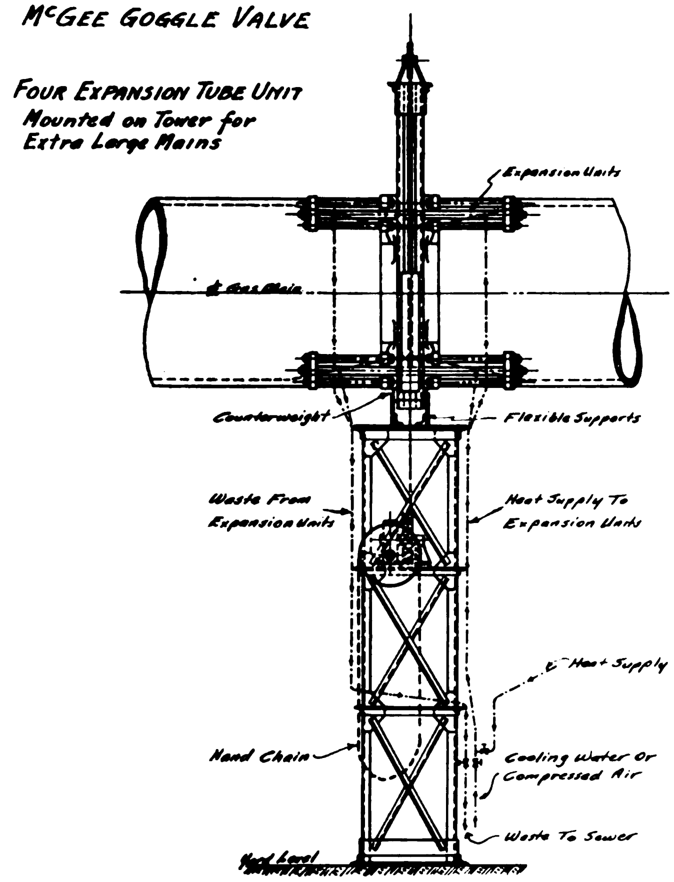

FIG. 3—*This drawing shows the four expansion tube unit mounted on tower.*

To operate, steam or other heating medium is turned on, the operator being stationed at hand chain. In one to one and a half minutes, the expansion tubes free the goggle plate sufficiently so that its movement can begin; the heating medium is then turned off and cold water or compressed air substituted, the expansion tubes then contracting and flanges clamp the goggle plate in open or closed position. Cooling water is required only until expansion tubes contract to seal goggle plate. Three to five minutes are required to complete the whole operation. In using steam as heating medium, exhaust valve for steam escape must be opened only sufficiently to remove condensation, for when valve is opened full for free flow of steam, pressure is reduced and therefore temperature, as steam temperature is dependent on pressure. If hot blast is used, install three-way cock in hot main so dust collected in piping connection can be blown free to atmosphere before sending hot blast to expansion tubes. With hot blast, use full free opening of exhaust valve as temperature is not dependent on pressure.

Alignment of flanges and mains is assured by aligning lugs with flexible plates at sides of main where not installed over tower and by flexible supporting plates where placed over tower.

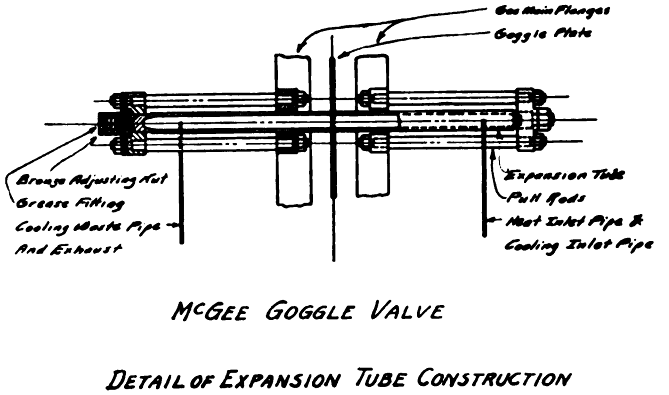

FIG. 4—*Shows details of the expansion tube construction, with the fluid connections.*

On crosshead at one end of each expansion tube, a hand adjustable nut is provided for initial adjustment in erection. Initial adjustment should be pulled up until valve is perfectly gas-tight, as the valve automatically returns to the initial tension after each operation. If the plant is completely down and no heat is available, the valve can be worked by hand, using adjustable nuts to clamp and unclamp goggle plates.

The internationally well known rustless steel expert, Mr. T. Holland Nelson has become associated with The Ludlum Steel Company, General Offices and Works, Watervliet, N. Y.

He is in a consulting capacity in connection with the production of rust and corrosion resisting iron and steel for which The Ludlum Steel Company has become famous during the last few years.

Mr. Nelson is also vice-president of the Wm. T. Bate & Sons Company of Conshohocken, Pa. He is well known as a Lecturer on rust and corrosion problems and has been intimately connected with the development of rustless steel both in this country and in England.

Mr. A. C. Dinkey, president of the Midvale Company of Philadelphia has returned from his winter vacation in Florida.

General Principles of the Beneficiation of Iron Ores*

By **T. T. READ**†

PART I

IRON ores may be defined as those substances from which iron may be made at a profit on an industrial scale. This definition is open to the objection that material which is not an iron ore in one place may be ore in another, and also material which is not ore at one time may be ore at another time. These objections are valid, but it seems best to adhere to the definition as given, because no one would engage in the making of iron from ore except in the expectation of making a profit from it. The making of a profit is so fundamental in the operations which are to be discussed in subsequent sections of this paper that it will be constantly reiterated.

The steel industry as a whole, and the blast furnace fraternity in particular are greatly indebted to the Bureau of Mines for the evidences of a very careful research into the difficult problems of blast furnace control and improvement.

Knowledge of the elements entering into the general problems was of first hand importance. This knowledge the Bureau of Mines had accumulated and presented in most understandable form; divided into appropriate studies, these articles have been published in this journal, as released.

In the drawing of conclusions from the premises as found, the authors have welcomed intelligent discussion and criticism.

Iron is, next after aluminum, the most abundant metal in the earth's crust. According to F. W. Clarke of the U. S. Geological Survey the igneous rocks contain 15 per cent alumina, and 6 per cent iron oxide or 4½ per cent metallic iron, on the average. Though iron ores are much more abundant than aluminum ores, E. C. Eckel has computed that only one ten-thousandth part of the total iron is in substances that could possibly be considered ores at the present time.

Metallic iron can not be considered an iron ore, although it occasionally occurs in large masses in basalt or lava flows, notably on Disco Island, Greenland. It is not uncommon in meteorites, but these are so rare that they are always put in museums when found. It has been stated that the metallic iron of meteorites suggested to primitive man the idea of reducing iron from iron ore, but this seems quite improbable. The iron of meteorites is usually high in nickel, and differs so in its properties from the soft sponge iron made by primitive reduction processes, that the early metallurgist would probably not have considered that they were related in any way. Generally speaking, natural metallic iron is a mineralogical curiosity, not an ore.

The easiest and cheapest way to produce iron from the substances containing it is to deoxidize iron oxide with carbon, which is abundant and cheap. The iron oxides are abundant enough and widely enough distributed so that no other method can compete at present, hence, under the terms of our definition, the oxides are the only iron minerals which are iron ore. Two apparent exceptions must be made, the carbonate (siderite) and the sulphide (pyrite). Both of these can be easily and cheaply converted into the oxide and under special circumstances are available as ores, though neither is of much importance in this country. They are discussed below in their proper place.

Iron Minerals.

Magnetite—Other things being equal, the best iron ore would be the one containing the most iron. Magnetite, Fe_3O_4, 72.4 per cent iron, is the oxide highest in iron. It is black and occurs in all conditions from loose sand to compact coarse or fine-grained masses. It is strongly attracted by a magnet, which is of great importance in its production. Magnetite ore deposits are discussed in detail in the various books on economic geology, especially in "Iron Ores" by Eckel,* who points out that magnetite deposits are usually associated with igneous or highly metamorphic rocks.

> When associated with crystalline limestone or with the acid igneous rocks the ore is commonly free from other metals; so that simple separation from the country rock or gangue will give a satisfactory product. But when magnetite occurs associated with basic igneous rocks, it is apt to have either mixed with it physically, or combined chemically, oxides of chromium or titanium. In these cases, though magnetic separation removes the non-metallic material, the product will still carry much or all of the metallic impurities.

Magnetite is locally important in the regions in which it occurs in sufficient abundance to be worked at a profit, but it amounts to less than 4 per cent of the total iron ore mined in America. In Great Britain, France, and Germany, the other three principal iron-producing countries, it is of even less relative importance. The iron ore deposits in Norway and Sweden, however, nearly all contain some magnetite and a number of them are wholly magnetite; no statistics or estimate of the relative amounts could be found. The assumption that magnetite constitutes somewhere between 4 and 6 per cent of the total iron ore production in Europe can not be far wrong; in other words, magnetite amounts to 5 per cent or less of the world's production of iron ore. The Appalachian Mountains in New York, New Jersey, and Pennsylvania are the principal producing regions of America.

Hematite—Hematite, Fe_2O_3, is next to magnetite in iron content and indeed approaches it quite closely, for its theoretical iron content is 70 per cent. The impurities and the moisture usually present bring the iron content down, however; and most of the hematite mined in America (and over 90 per cent of our ore produced is hematite) contains a little over 50 per cent iron (natural). The hematite ores which contain lime as an impurity form a special case, because over three units of limestone must be present in the blast furnace mixture to flux one unit of silica, consequently three units of limestone originally present in the ore and displacing three units of silica represent a gain of 12 units of limestone which will not need to be added to the charge. A hematite which contains less than 40 per cent iron and nearly 20 per cent silica would be unsaleable (except for special uses) in the Lake Superior District, where the ores contain practically no lime, but in Alabama a 40 per cent ore forms the basis of profitable smelting, because it there contains 10 to 11 per cent lime. It is not possible, therefore, to set any arbitrary standard of iron content for a workable hematite, for many factors must be balanced.

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*Published with approval of the Director, U. S. Bureau of Mines.

†Formerly Safety Service Director, U. S. Bureau of Mines, and Superintendent of North-Central Experiment Station, Minneapolis, Minn., now Assistant Secretary, American Institute of Mining and Metallurgical Engineers, New York City.

*Iron Ores, by E. C. Eckel, 1914, p. 24.

Hematites vary in color from a brilliant red to a steely black, and in consistence from an incoherent powder to material that is so dense that limited amounts of it are cut for use as semi-precious stones. More than two-thirds of the Lake Superior region production, or say 60 per cent of the total iron-ore production of the United States, is soft hematite. This is not the same as saying that it is 60 per cent incoherent powder, for although all the Mesabi district ore is called soft ore no inconsiderable percentage of it breaks in lumps as mined, just as soil when ploughed sometimes breaks into clods and sometimes as loose powdery material. When this material was first used in blast furnaces a good deal of difficulty was experienced in the management of the furnace, but as the technique was learned most of the difficulty disappeared except that inevitable in the handling of finely divided material in gas currents of high velocity, and, as will be pointed out later, there are certain advantages in the use of finely divided ore in the reduction process. For descriptions of the occurrence of hematite ores, their modes of origin, and other details, reference should be made to the work of Eckel, already cited.

Limonite—There are five hydrated oxides of iron, of which limonite is the most common and best known. They form a series, ranging from one molecule of water combined with two molecules of hematite (Fe_2O_3) to three molecules of water with one of hematite. They are sometimes all referred to as limonites, but the term "brown ores" as applied by Eckel is much better. Actually they range in color from a light yellow through brown and red to nearly black, so the name brown ores is only a roughly descriptive one. They are usually rather soft and open-textured. According to the amount of combined water they range from 66 down to 52 per cent iron and in the natural state usually contain much less because they are commonly impure and their open texture lends itself to mechanically held moisture.

There are two well-recognized types of brown ores; those that have been chemically precipitated from solution, usually called bog ores, and those which have resulted from sub-aerial decay of iron-bearing material, usually referred to as residual limonites, which may contain small amounts of copper, nickel, chormium, and other elements that were present in the original material. Where the original iron-bearing material has been a sulphide ore-body, the resulting iron ore is referred to as gossan. A century ago a large part of the iron ore mined in the United States was brown ore, but now it only makes up 2 or 3 per cent of the total ore mined. The brown ores of the northeastern United States on which the earliest smelting projects were based probably can not be considered much of an asset for the future, but the deposits in northeastern Texas (not now worked) and those of the Tennessee River basin and the Southern Appalachian region are reckoned as amounting to about one-tenth the known reserves of iron ore in the United States. The brown ores, because of their physical characteristics and rather low grade are peculiarly amenable to beneficiation and will be referred to again later.

Siderite—Siderite, carbonate of iron, when pure contains 48.3 per cent iron, but as it also contains 38 per cent CO_2 which can be driven off by calcination, it is theoretically a very good ore. It is not of much importance in America, however, because the only place in which it is generally found in workable quantities is in the Allegheny series of the Carboniferous, chiefly in Ohio, but also in western Pennsylvania, Kentucky, Tennessee, and Alabama. These beds were a fairly important source of ore 60 or 70 years ago, but the production has steadily declined until it only constitutes a few hundredths of one per cent of the annual production at the present time, and as the estimated reserves only constitute 0.5 per cent of the probable reserves of workable ore in America, they can safely be dismissed without further consideration. Indeed the only country in the world in which siderite is of much importance is England, where the Cleveland ores constitute about 70 per cent of the domestic ore production, or about 35 per cent of the pig iron production in England. The ore as mined averages about 30 per cent iron and by calcining is brought up to 40 or 42 per cent. As the ore contains an excess of lime and magnesia over that required to flux its silica, it is useful to mix with the silicious 48 per cent iron ores imported from Spain. With this important exception siderite is not an important ore of iron either from the standpoint of present production or future reserves.

Pyrite—Pyrite, FeS_2, which contains 46.7 per cent iron must be considered an ore of iron, since iron is made from it, although not directly. Pyrite is mined in considerable quantities and burned for the production of sulphuric acid. The residue of iron oxide, known as "blue billy," "purple ore," "pyrite cinder," and by other names, must be disposed of in some way, and it frequently contains enough copper to make its recovery worth while. After leaching to recover the copper the leached residue is either nodulized or sintered, which at the same time removes the last of the sulphur, and sold to blast furnaces. No figures are available as to the amount so used in America, but in England it yields about 4 per cent of the pig iron produced. If the same ratio holds in America, and it probably is less, pyrite is about as important as magnetite as a source of iron. At any rate, it is too important to be overlooked.

Importance of Hematite and Reserves of Iron Ores.*

The preceding review brings out clearly that at the present time hematite is the principal source of iron, and the known resources of it are large enough so that this condition is likely to persist for some time. Most of the hematite now produced is high enough in iron and free enough from impurities so it is melted directly; magnetite and brown ores, on the other hand, frequently occur in deposits of such a character that they require some form of preliminary treatment before smelting. In short, hematite usually requires no beneficiation, magnetite and brown ore usually do require it, siderite and pyrite cinder always require preliminary treatment before smelting. In the subsequent discussion beneficiation processes are subdivided according to the impurity they are intended to remove, rather than by the character of the ore to which they are applied. This presents some difficulties, but seems, on the whole, advantageous, because it permits the contrasting of different methods of accomplishing the same purpose.

The question is sometimes raised as to whether the rapid increase in the rate at which iron is being produced from ore (the amount produced between 1900 and 1925 exceeded the total amount produced in all history previous to 1900) may not result in a shortage of iron ore at some more or less distant time. The answer to this question is, in my judgment, definitely no, even though a distinguished Swedish geologist, in an official report in 1905, stated that we are likely to run short of iron within a single century, if we keep up the present rate of consumption.

The ores which are being worked at the present time are those from which pig iron can be made at a minimum cost, and as is elsewhere explained, they range from high-grade to low-grade according to the sum total of conditions that affect them. The general tendency, however, has been to utilize the highest grade ores, for reasons explained in more detail in the next chapter. Much of the iron that was made in America prior to 1870 was made from ores that are too low-grade to be worked at the present time, since cheap transportation has been provided for higher-grade ores. On the other hand, the high-grade ores of Brazil, which constitute perhaps one-fourth of the known reserves of present workable grade, are practically untouched, although their existence has been known for over a half-century. The statement sometimes made that the world is recklessly using up all its richest ore therefore seems almost absurd when we remember that over a third of the British production of pig iron is made from ore that in its natural state only contains about 30 per cent iron, while the Brazilian ore reserves, estimated at Merriam and Leith as over 7,500,000,000 tons, all over 55 per cent iron and half of it over 64 per cent iron, are practically untouched as yet and not likely to be drawn on at all heavily for many decades. The Newfoundland deposits, of 52 per cent iron, probably 4,000,000,000 tons; and the Cuban ores, about 35 per cent iron natural but which can be dried to commercial grade, say 3,000,000,000 tons, have also been but little mined as yet. The iron content is only one factor in arriving at the main consideration, which is to get ore that costs the least in the furnace, per unit of pig iron produced. The ores being mined at the present time are those from which pig iron can be made at a price to compete with other sources of supply.

In American practice about half the cost of the pig iron is the cost of the ore at the furnace, and one-third is the cost of the fuel for smelting. Over half the cost of iron ore at furnaces in the Pittsburgh district is the cost of its transportation. The ores now being used in the Pittsburgh district are those that can be laid down at the furnace at the least cost per unit of iron contained, provided they are of such a grade as not to increase the fuel cost much. If the price of pig iron increases relatively to other commodities lower grade ores can be used, but the increase must be a relative one.

The following statement occurs on page 394 of "Iron Ores" by E. C. Eckel, already cited:

> If, without improving manufacturing or concentrating methods, we simply assume that pig iron will rise in price a few dollars—say an average of $20 per ton in place of an average of about $14 per ton—this rise in price will admit to use ten times as much ore as is now considered available.

Eckel, of course, had in mind a relative rise in price, and not the general rise of price level that occurred in the following decade. The monthly average price of No. 2 Foundry pig iron at Chicago in the fourth quarter of 1922 and the first half of 1923 was around $30 per ton, but this did not admit lower grade ores to utilization, because the purchasing power of the dollar, based on cost of living, was in 1923 less than two-thirds of what it was in 1914 when the same grade of pig iron averaged $15 per ton at Chicago. Pig iron must advance relatively to other commodities, especially transportation and fuel, if lower grade ores are to be utilized. It is nevertheless true that if we admit the possibility of a sufficient relative advance in the price of pig iron there is no fundamental reason why the 67,000,000,000 tons of iron formation containing over 35 per cent iron, as estimated by Leith and Mead* may not eventually be utilized as iron ores.

Another reason why alarm need not be felt as to the future supply of iron is that iron, unlike coal, is a commodity that is not destroyed by use, but is available for re-use until finally destroyed by rusting and other sources of loss. Hadfield estimates that of the total iron and steel in use about 3½ per cent is annually destroyed by rusting and 2 per cent additional is worn out or discarded as obsolete. The production of steel in the United States had during the past decade exceeded the pig iron production for each corresponding year by 10 to 20 per cent, despite the fact that one-third or more of the pig iron is used as such and not converted into steel. The difference is, of course, made up by remelting of old iron. It seems unquestionable to the writer that as time goes on the remelting of old iron will become more important, while the loss through rusting will be decreased through the intensive study being given to corrosion prevention. Concrete is being increasingly used in place of steel for bridge and building construction, copper and zinc for roofing and building accessories, and in a variety of other ways the demand on iron

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*Readers are here reminded of the paper "Iron Ores of the World," by O. R. Kuhn. *The Blast Furnace and Steel Plant*, vol. 14, January, 1926, pp. 2-12.

*Van Hise, C. R., and Leith, C. K., The Geology of the Lake Superior region. Monograph 52, U. S. Geol. Survey, 1911, p. 492 (W. J. Mead).

and steel is being relatively lessened, although the use per capita increases.

A specific example will make this argument clearer. A man who had never owned an automobile buys one and thereby creates a market for new iron. When his automobile is old he exchanges it for another, but does not thereby create an additional market for iron. He merely trades old iron for new. If he scraps his old automobile and buys an airplane he may throw more iron back on the market than he takes off. To a large extent the production of iron from iron ore is the production of a permanently usable metal; it is not, indeed, inconceivable that in the far distant future the prevention of rust and the use of substitute materials for iron may reach such a degree of development, that relatively little new pig iron may be required. This is simply a speculation, but it is at least equally as probable as that there will ever exist a serious shortage of iron.

Ores and Metallurgical Processes.

Consideration of processes for the preparation of iron ores for subsequent metallurgical treatment presupposes a decision as to what the method of metallurgical treatment is to be. In considering the methods that may in the future be applied to the treatment of iron ores, to render them fit for metallurgical reduction, it is necessary to consider whether the metallurgical processes to be employed in the future may perhaps also differ in important ways from those employed at the present time. To this end it will be desirable to review briefly the methods that have been used in the past and how current metallurgical practice has devedoped.

Early Metallurgy.

It is generally agreed by archeologists that man's first knowledge of iron was acquired from the discovery of fragments of meteorite, and that primitive men were led up to the production of iron from ores by first acquiring a knowledge of how to smelt the mixed ores of copper and tin that yielded bronze. Metallurgists consider that the archeologists are mistaken in their views; the view of the metallurgist is most clearly expressed in the historical note on iron smelting which occurs as a footnote to H. C. and L. H. Hoover's translation of "De Re Metallica", which argues that all the earliest produced iron has probably been destroyed by rusting, that the oldest Egyptian texts extant refer to iron, and that the production of iron is so much easier than the production of bronze that it seems probable that it would be learned earlier. Much of the archeological discussion is not at all germane to our purpose. Some of it, indeed, to a metallurgist, seems entirely unprofitable; such as, for example, discussions as to in what way a knowledge of smelting was transmitted from one region to another. It seems altogether probable that the methods used in any given region may have been independently evolved by the people of that region in the course of their industrial development without the necessity of having knowledge of the methods used in other regions communicated to them from outside.*

Hough† has argued that the development of iron smelting has chiefly depended on the development of forced draft apparatus on the ground that the smelting or iron ore is impossible without forced draft. The reduction of iron ore to iron with natural draft is not difficult, and has been practiced for centuries by the Chinese, as the writer‡ has elsewhere described, while the placing of medieval English iron furnaces on the sides of hills to increase the draft is described by Manchester.§ The essential point to remember is that all the earliest processes for the production of iron from its ores involved only the reduction of the iron oxide to metallic iron, without fusion. The iron thus produced was sorted out and worked into objects of usable size by means of heating and hammering. It was not until considerably later that through the aid of improved furnaces and improved blowing apparatus, by means of which higher temperatures could be reached, it was found possible to produce a metal high enough in carbon to give a low enough melting point so that it could be drawn from the furnace in the fused state and cast. This was an enormous improvement in the metallurgical processes because it was inevitable that iron produced by the method first described would contain large quantities of solid non-metallic impurities. To these impurities as they exist even in the metal produced by the best processes of today, H. E. Hibbard has given the name "sonims" (a valuable term that deserves more general use) and they will hereafter be referred to by that term. A fused metal would obviously be much freer from sonims than would metal produced by the heating and hammering of solid particles of metal to which there remained attached a considerable proportion of the original non-metallic constituents of the ore. So slow was metallurgical progress however, that it was not until the fourteenth century that smelting ore to pig iron in the blast furnace began to be used on any extensive scale. Charcoal was universally used as a fuel in the blast furnace, and it was not until 1735 that Darby showed how to make pig iron with coke. Prior to the fourteenth century the typical product of iron metallurgy was wrought iron, from which steel was made by cementation.

Removal of Carbon from Iron.

Some time in the sixteenth century it was found possible to remove from the iron-carbon alloy made in a blast furnace, some, or all of the carbon which it contained, and thus the production of wrought iron on an increased scale was made possible. The wrought iron made by either of these two processes, while suitable for most of the uses of primitive man, was too soft to meet many of the needs of a developing civilization, especially for swords, knives and armor, and early in the history of the art a process was devised by which, after the soft metal had been hammered, scraped, or otherwise brought into the desired shape, it could be made hard. The cementation process met this need and by these processes it was possible to produce iron and steel in sufficient amounts, and of the desired quality, to meet the needs of civilization prior to the development of the steam engine (between 1760 and 1770) and the railway. The steam engine called for quantities of iron and steel in excess to those previously required, and the development of railway transportation immensely accentuated this. The first railways had wooden rails bound with iron, but it early became evident that iron rails would be essential. In order to permit the rapid development of railway as a means of transportation it became essential to produce iron in large quantities at a low price and none of the methods then in use would meet this need. The invention, in 1856, by the late Sir Henry Bessemer, of the process which bears his name, by means of which the carbon content of pig iron can be cheaply and quickly burned away, solved this problem. Since that time the two criteria of iron and steel making have always been low cost of production and uniformity of product.

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*Belck, W., Die Eiginder der Eisenteknik. Zeit fuer Ethnologic, vol. 42, 1910, pp. 15-30.

†Hough, Walter, Prac. Nat. Acad. Sci., vol. 2, 1916, p. 127.

‡Read, T. T., Trans. Amer. Inst. Min. Eng., vol. 43, 1912, p. 11.

§Manchester, H. H., Eng. Min. Jour.-Press, vol. 116, 1923, p. 154.

Uniformity of Product in Iron.

It is desirable to point out here that uniformity of product was not a necessary condition of early iron metallurgy. In the small-scale methods used in early times, and with the low wages which then prevailed, it was easy to utilize iron and steel of variable quality. The iron-maker who produced a superior product was able to realize an increased price for it, but the product of inferior quality was also saleable and there was no demand for the production of large quantities of material of uniform grade. Under modern conditions, however, strict control of operations is an absolute necessity. In the production of a single model of automobile, which is manufactured at the rate of more than 7,000 a day, any individual part of the mechanism must not only be exactly interchangeable as to size and shape with all other parts of the same kind, but it must be identically the same as to composition and quality. In the production of the front axle of these automobiles more than 100 tons of steel is used per day and this steel should, so far as it is humanly possible, be identically of the same composition, not only throughout the day but on every day of the year. This is of course an extreme case, but represents the tendency of the modern industry to call upon the iron and steel industry for the production of metal of uniform composition and quality in large amounts. It does not seem likely that this demand will in the future be lessened and it must, therefore, be taken into account in considering the probable future development of metallurgy of iron and steel.

Limits of the Blast-Furnace Product.

Considering first the production of iron in the blast furnaces, while it is possible to vary over a considerable range of characteristics of the product thus made, there are also limits within which the blast furnace must work. The reduction of the iron oxide and its fusion to metal while in contact with solid carbon makes it inevitable that the resultant product will contain a considerable amount of carbon. In ordinary practice the carbon content is from 3 to 5 per cent nor is it possible to go much below this, and it is, of course, not desirable to go higher because carbon is thus consumed uselessly. The strong reduction which exists in the blast furnace (and which is necessary for the elimination of the sulphur) makes it inevitable that various other substances which are present in the ore will be reduced and if they are soluble in the cast iron will be present in it. This is unfortunately true of phosphorus, which if present in iron ore, is reduced and goes into the pig iron. The sulphur present also accompanies the iron in some degree and its removal later is extremely difficult. Various metallic impurities act in the same way and the whole tendency of the ironmaking process has been to secure, if possible, pure ore for smelting in the blast furnace rather than rely on the elimination of impurities by later treatment.

Bessemer and Open-Hearth Processes.

This is not the case, however, with the basic-Bessemer process, which was invented by Thomas as a means to permit conversion into steel of pig iron that is high in phosphorus. In this method the presence of the phosphorus is essential to permit the basic-Bessemer operation to be carried out, and for that reason ore that is high in phosphorus must be used. Ores that are high enough in phosphorus for this method are not abundant. The basic-Bessemer process was never used to any extent in the United States and has now practically gone out of existence here.

The Bessemer process, useful as it was for the production of large quantities of cheap steel low in carbon, also has its limitations. The acid-Bessemer does not eliminate any phosphorus, and there very early came into general use the term "Bessemer ores" to designate those ores which were low enough in phosphorus so that the resultant steel produced by the acid-Bessemer process would not contain over 0.10 per cent phosphorus, which was arbitrarily set as the limit of the phosphorus content of steel. It is not possible, however, to make steel of more than a moderate carbon content by the acid-Bessemer process because the method of recarburizing is such that it is difficult to obtain a uniform product if considerable amounts of recarburizing material have to be added.

The open-hearth process has two advantages as compared with the Bessemer process. The design of the furnace and the character of the operations are such that it is possible to add a large amount of scrap to the furnace and under modern conditions the amount of scrap which requires to be remelted and reworked is continually increasing. The longer time required also permits the charge to be held in the furnace until the recarburizing operations have time to complete themselves, and also, to permit the making of tests to determine the extent to which the operaion has proceeded, thus giving more accurate control. The acid open-hearth is a little more flexible than the Bessemer, because deoxidation is accomplished by the addition of ore, roll scale, or other form of iron oxide and if this material is low in phosphorus it serves to bring down the average content of the charge. A similar function is performed by the addition of low-phosphorus scrap.

The basic open-hearth is more flexible still, because the slag is so high in bases that it is able to take up and retain phosphorus and sulphur and this gives a wider latitude in the character of the material used. But this involves recarburizing the steel as it is being poured out of the furnace into the ladle, because attempting to recarburize in the presence of the phosphorus-bearing slag would cause the phosphorus to go back into the steel, and this of course, makes it more difficult to control recarburization. For this and other technical reasons which need not be gone into here, basic open-hearth steel is not so free from sonims as acid steel.

In the endeavor to combine the advantages of different processes two-stage and even three-stage operations are conducted, such as, for example, oxidizing the silicon, manganese, and most of the carbon in an acid Bessemer, then dealing with the phosphorus and the remainder of the carbon in the basic open-hearth. Another "duplex" process is the elimination of the silicon and phosphorus in a basic open-hearth and then transferring the metal to an acid open-hearth to finish it. Even triplex processes are used, the final refining process being done in an electric furnace. Through ingenuity and skill combinations of advantages may thus be derived, but complication of processes inevitably increases cost except under the most careful control. Increase of cost is, of course, permissible so long as it is accompanied by a more than compensating increase in quality.

Electric Furnace for Steel Making.

The use of the electric furnace in steel-making calls for brief reference at this point. Large claims have been made for the advantages attached to the electric furnace. All experience up to the present time indicates that as a means of making pig iron from iron ore, it can not compete except where fuel prices are prohibitive. Carbon for the reduction of iron oxide to iron must be supplied in any case, the electricity merely being a source of heat, and the high construction cost per unit of capacity makes the process expensive. In steel-making the case is different, for the ability to produce heat without bringing carbon into play may be distinctly advantageous. For making small quantities of high-grade or special steel the electric furnace has distinct advantages, and nearly 400 electric furnaces have been built in America since 1915. Many of these are simply melting or refining furnaces, and it does not seem probable that in the near future the electric furnace will play any large part in the initial production of steel from pig iron.

Necessity of Preliminary Treatment of Raw Materials.

Various processes have been proposed for the direct production of steel from ore. It is evident from the review above that the demand from industry for large quantities of steel of uniform and high quality has been of increasing importance, and high quality means not only freedom from chemical impurities but also from sonims. It is a general rule of technology that a high-quality product can not easily be made from crude material in a single step. The refining process is like the mathematical concept of a variable approaching its limit. The first step takes out most of the impurity, the second takes out most of the remainder, the third removes most of the residue, and so on till any desired degree of purity is attained. To make a high quality product from ore in a single step, therefore, would involve having a high-quality ore to start with, or the use of preliminary processes to improve the quality. The possible production of metal from low-grade ore without preliminary beneficiation is described in more detail under Elimination of Oxygen from Ores.

This brief review of the metallurgy of iron is intended to demonstrate that the demand of modern industry is for steel of high quality, uniform quality, and in large amounts. This demand has chiefly been met by the use of pure ores, which easily yield a high quality product. The purest ores are rapidly being used up; the production of high-grade metal from the lower-grade ores will in the future require either elaborations of the metallurgical process or subjecting the ores to preliminary purification processes before attempting their metallurgical treatment; which method should be adopted in any given case will depend on the cost and the result. The principal factors involved in the production of iron from ore are briefly reviewed in the next section, "Factors Influencing the Utilization of Iron Ores."

Factors Influencing the Utilization of Iron Ores.

Cost of Producing Steel—The axiom on which the subsequent discussion will be based is that iron and steel production is a competitive business. The fundamental factors in competition between iron and steel producers are price and quality. Price is put first because there are standard grades of quality and if the product meets these, price becomes the governing factor. Various other considerations, such as ability to make specified sizes and shapes, or to deliver a specified quality by a given date, while important in an individual transaction, are not fundamental, as are the other two. Quality has already been discussed and will be referred to again in discussing the effect of impurities and their elimination. It is desired for the present to concentrate attention on price. The price at which steel can be sold depends on its cost of production (operating cost) and the cost of doing business or "overhead" which includes such factors as capital invested, selling cost, taxation, etc. The latter, while important to a steel-making and selling company has nothing to do with this discussion, beyond noting the fact that a company with a low cost of doing business is at an advantage if its production cost is average, and can compete on equal terms if its production cost is as much higher than its competitor's as its cost of doing business is lower. On the other hand, a company with a high cost of doing business can only compete if its production cost is enough lower than its competitor's to enable it to meet them on the total.

The cost of production of steel is made up of a variety of factors; the cost of the raw material (pig iron), fuel, labor, maintenance and renewals, interest and depreciation on plant, and a variety of others. The cost of the raw material constitutes roughly two-thirds or three-quarters of the total. (Steel is, of course, also made from scrap, but the cost of the scrap eventually leads back to its production cost.) The cost of pig iron, therefore, appears to be the most important factor in the iron and steel business.

Oxygen in Iron Ore and Its Removal.

The objectionable constituent of iron ore which is present in the largest amount, and which costs the most to eliminate, is oxygen. The whole blast-furnace smelting process is designed to free the iron from the oxygen; ridding the iron of the other impurities is only accessory to and subordinate to the main deoxidizing operation. Roughly speaking, iron ore can be delivered at blast furnaces for about one-half cent per pound of iron contained; to free the iron from the oxygen that is combined with it also costs about one-half cent per pound. It is evident that deoxidizing is so important a process that schemes for beneficiating iron ore cannot be separately considered, but must be considered in relation to that essential process.

Oxygen is not ordinarily thought of as an objectionable constituent of iron ore, for it is always present and has to be accepted, just as the climate of a community has to be accepted. It differs in a fundamental way from the other common impurities in that it is actually chemically combined with the iron, while the others are usually only mechanically mixed and can, therefore, be attacked by mechanical processes, while the oxygen will only yield to chemical attack. The practically universal method for removal of the oxygen is by smelting the ore with coke in the blast furnace. What happens here is that hot carbon monoxide (CO) passing up the blast-furnace stack, down which the ore is descending, reacts with the oxygen of the ore and reduces the iron oxide to metallic iron. At the bottom of the stack coke is burning in heated air under conditions which cause it to burn to CO. The CO passes up the stack to eliminate the oxygen of the ore, while the metallic iron is melted by the intense heat at the bottom, and is drawn out in the liquid state. Silica and alumina, two other important impurities, are also fused by the heat, forming with the lime, that has been added to the charge for that purpose, a liquid slag that is also drawn out. Most of the sulphur present also goes out with the slag. Elimination of the silica, alumina, and sulphur in this way is accessory to the main purpose of deoxidation and this fact must be kept in mind in the subsequent discussion of these impurities. It should be noted that water, another objectionable impurity of iron ore, is also eliminated early in the operation. Phosphorus is the only impurity that is unaffected. It may be said that blast-furnace smelting, an operation designed to remove oxygen from the ore, incidentally removes the other impurities more or less completely, with the exception of phosphorus.

The oxygen-removing operation, roughly speaking, involves the assembling at one place of about two tons of ore, one ton of coke, half a ton of limestone, and eight tons of air (at different pressure to penetrate the charge column). The surplus heat from the combustion of the coke is sufficient not only to generate the power for the air blast, but also to heat it to a high temperature so that the only factors in the place problem are ore, coke, and limestone, and since the limestone is small in amount in proportion to the other two it usually exerts but little weight in the balance between coke and ore. In the early days when forests were abundant and charcoal was the common fuel, smelting furnaces were as a matter of course built conveniently near the orebodies. When charcoal became too expensive, except for certain grades of pig, and coke came into general use as a fuel the decision where to build a blast furnace involved the solution of an equation containing variables; the cost of transport of the coke, of the iron ore, and of the resultant pig iron to its market. As regions which produce fuel in abundance are usually regions of high industrial development and consequently afford good markets for pig iron, the common solution is that it is most profitable to transport the ore to the place where the best balance exists of coke and pig iron transport. In this way it comes about that most of the ore produced in the Lake Superior region is transported on the average a thousand miles to regions of great industrial activity for smelting. In Alabama, ore, fuel, and limestone fortunately occur in the same neighborhood, but this happy combination is rare. Wyoming iron ore is hauled to Colorado for smelting where it is nearer the coke supply and also to the largest local markets for iron and steel. Ore from Chile, Sweden, and Cuba is brought to plants near the Atlantic seaboard for smelting In American practice it is iron ore which generally has to stand the long haul.

Impurities in Iron Ore and Their Role in Transportation and Metallurgy of Iron.

Silica—The long haul is an important factor in the utilization of iron ore, for transport cost on every pound of impurity represents a loss for which there is no compensation. Taking Lake Superior ores as an example, every unit (20 lb.) of silica in a ton of iron ore delivered to lower Lake ports represents a two cent transport cost on something which not only has no value, but has a negative value, for it not only involves a cost for its removal, but also increases the cost of the deoxidizing operation. One unit of silica will require for its fluxing three and one-third units of limestone, and not only will displace altogether four and one-third units of iron ore in the smelting charge, but will absorb nearly as much heat as smelting the ore would have. The same kind of reasoning applies to alumina, and on the face of it, it looks as though the more silica and alumina that can be eliminated at the point of origin of the ore, the better. The real solution is not quite so simple as this, however, as will be seen in discussing methods of beneficiating ores to eliminate silica and alumina. An important factor, later to be considered in more detail, is the physical form in which the silica and alumina occur. Alumina is commonly in the form of admixed clay, which is relatively easily washed out, silica is sometimes in the form of separate incoherent grains, as in some western Mesabi ores, but often is so thoroughly disseminated through the ore and so firmly coherent that mechanical separation is difficult or even impossible. In parts of Germany a hydrous iron-aluminum silicate is smelted for iron, as the grains are cemented together with a calcareous cement. But, except under unusual circumstances such as these, an ore in which the silica is chemically combined with the iron is not likely to be capable of being smelted in competition with the oxide ores.

Phosphorus—Phosphorus is a recalcitrant constituent of iron ores, because it passes through the blast-furnace operation undiminished and appears in the pig iron in the full amount that was originally present in the ore. In pig which is to be converted into steel by the Bessemer process this is very objectionable, for the phosphorus passes through the steel-making process and appears in the steel, which it makes brittle. The same is true of the acid open-hearth, but in the basic Bessemer a new set of conditions appear. For the operation of that process the pig iron must contain at least two per cent of phosphorus, and so we have the odd situation that the phosphorus must either be low or high, the middle range being unworkable except in the basic open-hearth. Ores in America are not usually high enough in phosphorus to be suitable for the basic Bessemer, and as the process is somewhat more difficult to operate all pig that is too high in phosphous for the acid processes is handled in the basic open-hearth.

In some cast-iron objects the presence of phosphorus is desirable, as it makes the molten metal more fluid, so that it fills the mold better and makes a sharp casting. The writer has elsewhere described how the Chinese introduce phosphorus into pig iron in order to make it cast better. The amount of material in which this factor is involved is so small that it is almost insignificant.

Water—The water content of iron ores is important if the water is chemically combined as it is in the limonites and other hydrated ores. It is the general practice to remove this water more or less completely by calcination preparatory to blast furnace smelting and it will be considered in detail in a later chapter. Ores in which the water is present as a physical mixture offer a problem in balancing the cost of dehydrating before shipment as against dehydrating at the point of smelting, as well as dust losses in shipment.

The carbonate ores are no longer of much importance in the United States and they constitute such a small fraction of the reserves anywhere in the world except in England that it does not seem necessary to do more than mention them.

Sulphur—Sulphur in iron ores has a sort of left-handed importance. The sulphur which is present in the coke is the really important item, as will be seen in the chapter on sulphur. It is desirable that the sulphur in the ore shall be low in order not to add to the coke-sulphur problem, for the pig iron ought not to contain over 0.1 per cent sulphur. The furnace man has some control over this, for a slag high in lime will carry away sulphur as CaS, but to make a high-lime slag run freely the furnace temperature must be high. This introduces complications as to the silicon content of the pig iron, which are discussed in more detail in a later chapter and in works on metallurgy. Furnace men agree that the best way to make pig iron low in sulphur is not to let the sulphur get into the material charged into the furnace. It is relatively seldom that iron ores contain enough sulphur to be objectionable were it not for the sulphur added to the charge by the coke. Sulphur is distinctly a blast furnace problem and is discussed in more detail later.

Manganese—Manganese in iron ores offers a problem because of its metallurgical behavior. If an ore high in manganese were smelted in the blast furnace and the resultant pig iron converted into steel by the Bessemer process, 25 to 40 per cent of the original manganese content would be lost in the slag of the blast furnace and the remainder would be eliminated in the Bessemer converter. On the average, 13 pounds of manganese is required to be added in making a ton of steel, but it must be added; manganese in the original ore is of no advantage execept in certain modifications of the open-hearth process, where it is used to aid in sulphur elimination. Unless the manganese in an iron ore is high enough for spiegel manufacture (which usually means that it must be 15 to 20 per cent Mn. and not over eight per cent SiO_2) it is not a very valuable constituent and manganiferous iron ores can only be sold in limited amounts for the purpose mentioned above. Many ores which are high enough in manganese to use for spiegel-making are too high in phosphorous and silica for that purpose, but may be used in increasing the Mn content of basic pig iron. Mangenese is discussed in more detail in a subsequent chapter.

Titanium—Titaniferous iron ores are chiefly interesting because of the peculiar ideas that at one time existed regarding them. Not many years ago there was a somewhat general belief that enormous deposits of titanium-bearing magnetites were available to the metallurgist's hand if he could only learn how to smelt them. More careful consideration has revealed that no difficult technical problem seems to be involved in the smelting of such ores, other than that they usually require more fuel per ton of pig iron produced. It has already been pointed out that two-thirds of the cost of making pig iron from ore is the cost of the fuel. Magnetite only amounts to about five per cent of the total iron ore produced in the world, so it does not seem probable that the titaniferous magnetites are likely to ever prove of great importance. In this connection the following quotation* is of interest:

> The outlook for most of the deposits of titaniferous iron ore in the United States is not promising. As a rule the deposits are relatively small and of irregular extent and distribution. Further, they are lean to medium grade, and inaccessibly situated as regards transportation facilities.

Principal Factors Affecting Utilization of Iron Ores.

This brief review that the principal factors affecting the utilization of iron ores are, at the present time, transportation and their iron content. Half of the cost of pig iron is the cost of the ore at the furnace. Two-thirds of the other half of the cost is the cost of the fuel used in smelting the ore. As a large part of the cost of both fuel and ore is transportation it appears that this is the principal item in iron making. As both transportation and fuel cost per ton of pig iron produced are vitally affected by the iron content of the ore this is the next most important item. It is not possible to make pig iron at any given place at a profit unless it can be made there more cheaply than it can be transported from some other place. More accurately, pig iron is made at the place where the sum of the cost of the pig plus the cost of delivering to market is a minimum. The purpose of beneficiation of ores is to lower the cost of pig, or to put it another way, to permit ores to be used for iron-making that could not be used in their original state because the cost of the resultant pig iron would be too high.

In his review of Lake Superior iron-ore mining during 1925, Dwight E. Woodbridge† states that there are now 45 plants for beneficiating ores by washing, jigging, crushing, screening, magnetic separation, or by sintering. About 20 per cent of the shipments (54,000,000 tons in 1925) are products of these plants.

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*Eng. Min. Jour.-Press, vol. 121, January 16, 1925, p. 87.

†Singewald, J. T., The Titaniferous Iron Ores of the United States. Bull. 64, Bureau of Mines, 1913, pp. 145.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, ETC., OF

The Blast Furnace & Steel Plant

[Required by the Act of Congress of August 24, 1912]

Name of Publication: **The Blast Furnace and Steel Plant**, published monthly at Pittsburgh, Pa. [Report for April 1, 1926.]

Publisher—The Andresen Co., Inc., 108 Smithfield St., Pittsburgh, Pa.
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Business Manager—L. L. Carson, 108 Smithfield St., Pittsburgh, Pa.
Names and Addresses of stockholders holding 1 per cent or more of total amount of stock:

L. L. Carson, 108 Smithfield St., Pittsburgh, Pa.
F. C. Andresen, 709 House Bldg., Pittsburgh, Pa.
C. J. Keller, 5840 Solway St., Pittsburgh, Pa.
M. M. Zeder, 108 Smithfield St., Pittsburgh, Pa.
R. H. Thiess, 426 Byrne Bldg., Los Angeles Calif.
Known bondholders, mortgagees, and other security holders holding 1 per cent or more of total amount of bonds, mortgages, or other securities: None.

L. L. CARSON, Business Manager.

Sworn to and subscribed before me this 31st day of March, 1926.

CHAS. A. SEIBERT, Notary Public.
(My commission expires March 6, 1927.)

SHEET AND TIN PLATE

The Bliss "Cluster" Mill

A Cold-Rolling Mill of Unusual Design for the Production of High-Finish Monel Metal and Nickel Sheets at Huntington, W. Va.

By LLOYD JONES*

THE design and installation of the Bliss "cluster" mill provides an interesting story of an unusual construction patented and developed by the E. W. Bliss Company to a point where it has proven highly successful in the modern mill operations carried on at the Huntington Works of the International Nickel Company.

The mill known as the "Cluster" type, is so called on account of the unique arrangement of the rolls. The names of mills are somewhat typical of their design, for when one speaks of a two-high mill or a three-high mill it is quite generally understood to refer to the number and position of the rolls. In this particular mill six rolls are used, but we cannot call it a six-high mill because the rolls instead of being arranged on a vertical center-line are grouped close to the center of the housings and therefore the word "cluster" serves particularly well as the descriptive name.

The Huntington sheet mill was originally designed to produce hot rolled Monel Metal and nickel sheets for various purposes, particularly where resistance to corrosion was a controlling factor. These sheets were produced under the regular steel mill processes with a limited amount of cold rolling. Development of a market for highly finished sheets and sheets of refined grain structure for deep drawing necessitated additional cold rolling over that provided for in the original installation. Experimental work on regular two-high mills (26 in. by 56 in.) showed that the number of passes necessary to produce the required result made the use of two-high type mills commercially unfeasible. The International Nickel Company, in the course of their investigations into this problem, came in contact with the Bliss Company, who recommended to them the use of the cluster mill. The development of the cluster mill made it possible to duplicate in Monel Metal and nickel the same qualities and sizes of material as are furnished in brass, copper and nickel silver at a cost that would place cold rolled Monel Metal and nickel sheets on a price basis that is not prohibitive.

The design of the mill presented difficulties, as it was a somewhat radical departure from the usual construction, as will be noticed by examining the diagram of the arrangement of the rolls. The working rolls are of hardened steel 12 in. in diameter and the backing up rolls are of chilled cast iron about 24 in. in diameter. All of the backing up rolls are adjusted for alignment. The bottom rolls are adjusted by means of wedges under the bearings, the top rolls by screws which are placed at an angle so that their center lines will coincide with the angle of pressure on the rolls. To operate these screws, a special screw-down was designed powerful enough so that an operator could drive the rolls together with great force. In fact, the screw-down is so powerful that an operator can adjust the rolls while the sheet is going through the mill. To transmit sufficient power to these working rolls, we abandoned the old type of pinion housing and arranged drives on both sides of the roll stand. The drive on one side operates the top working roll, the drive on the other side operates the bottom working roll. These two drives are connected to one motor by means of a connecting shaft which insures the driving of both working rolls at the same speed.

The principal features and advantages of this construction may be analyzed as follows:

First—Greater reductions possible on sheets because of the small diameter of the rolls which are in contact with the sheets.

Second—Less power consumption as more energy is used in reducing the metal and less energy consumed by friction.

Third—Low roll cost as the working rolls are small in diameter, consequently light in weight and have an exceedingly long life on account of being hardened steel.

Fourth—Fewer dressings of the working rolls as they are extremely hard and are, therefore, not marked by defective sheets.

Fifth—Practically no distortion of the working rolls, as these rolls do not have any bearings, consequently there is no neck friction to heat up and swell the ends of the rolls.

Sixth—By supporting each working roll with two backing up rolls, rolls of very small diameter can be used as they are supported both in a vertical and horizontal direction. In other words, it is impossible for the working rolls to get out of alignment.

Seventh—By the use of two backing up rolls for each working roll, the enormous pressure necessary to reduce the sheets is divided between two roll contact surfaces. This reduces the contact pressure on the chilled iron backing rolls, prevents the spalling of the chilled iron surface and greatly increases the amount of rolling for each regrinding of the backing up rolls. The pressure is also distributed to four near bearings

(Concluded on page 201)

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*Engineer, E. W. Bliss Company.

Lining Furnace Bungs

By **MEREDITH F. KING***

IN the plant of the Canadian Steel Foundries at Montreal, annealing furnace bungs of large dimension are used. The bung casting has a span of 11 ft. 3 in. and is 2 ft. 6 in. wide, with a total weight when lined of approximately 6,635 lbs. For many months past this concern has adopted monolithic linings in place of fire brick for these bungs, on account of

1—Lower cost of refractory material,
2—Lower labor cost,
3—Greatly increased service.

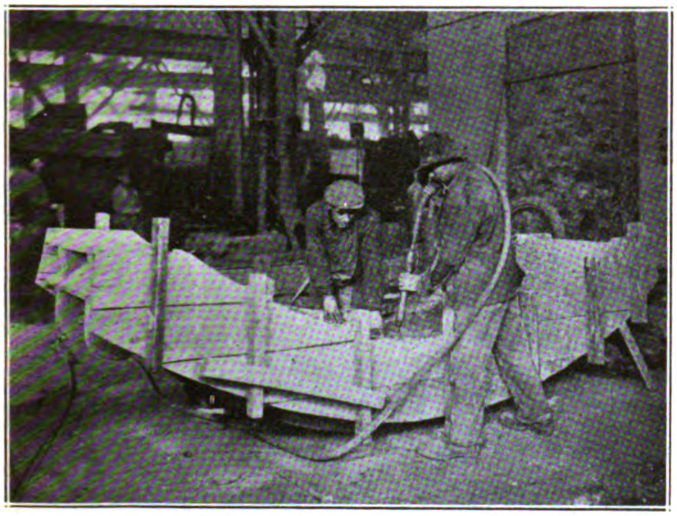

FIG. 1—*A wooden form is used when ramming the monolithic lining in place.*

The monolithic lining consists of crushed old fire brick, bonded with high temperature cement mixed in proportion to make a plastic mixture which is rammed with an air hammer into the bung casting, to a depth of 9 in., in place of laying up fire brick in these castings to the same depth.

A wood form is used as shown in Fig. 1. This form is made of rough 1 in. stock which is clamped securely with 2 x 4 braces against the sides of the casting and securely fastened by wire ties drawn tight. These forms can be repeatedly used for relining a group of bung castings.

It is the practice of this plant to have a reserve supply of bungs, and as soon as one is out of service, it is relined in the manner described. The newly lined bungs are usually placed on top of a core oven for 3 or 4 days for drying, after which they can be easily handled. They are then placed to one side and allowed to air set thoroughly for about 3 or 4 weeks. A sufficient number of bung castings are kept on hand so that an ample supply of lined bungs is always ready for service.

Lining.

The bung is first placed in the position and the form securely clamped in place. Before ramming in the mixture of crushed old fire brick and high temperature cement, the interior face of the bung casting is painted with a batter of high temperature cement which bonds the rammed-in mixture to the casting.

The refractory material used, is crushed old fire brick reduced to approximately ¼ in. mesh, including the fines. This material is put in a cement mixer, along with diluted high temperature cement in proportions of 3,000 lbs. of crushed fire brick to 1,000 lbs. of high temperature cement. To each batch of this size is added a half bag of Portland Cement when the mixture is about ready for ramming.

The mixture is then dumped in between the sides of the form to a depth of about 4 in. This material is then rammed, using a sand air rammer. Ramming is not done directly on the material itself, but against a piece of board which is shifted about to get an even distribution of pressure.

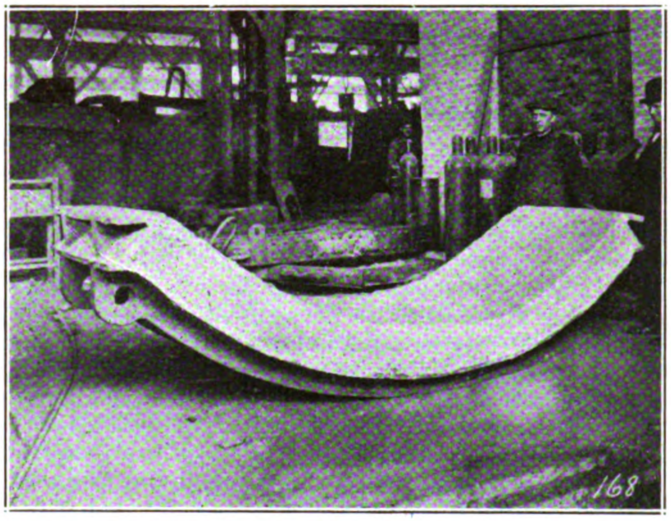

FIG. 2—*Furnace being lined and ready for drying.*

Labor Saving.

It has been found that with the monolithic lining, three men can ram four bungs in a day. With fire brick lining, as formerly used, it required one bricklayer and three or four laboreres to line one bung in a day.

Service of Monolithic Bungs.

The majority of the bungs lined by this method have been good for thirty heats of service. This is a fair average. Prior to this, 10 heats was considered especially good for fire brick lining, though the average life would probably be from six to eight heats.

Strip Steel

A small piece of strip steel, .0012-in. thick and ⅛-in. wide, is mounted in a leaflet by Edgar T. Ward's Sons Co., Philadelphia, illustrating what can be done in the production of fine steel. The small strip was rolled by the Uddeholms Company, Ltd., Sweden.

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*Service Engineer, Quigley Furnace Specialties Company, New York.

CURRENT REVIEW

The Manganese Situation

The Russian Soviet Government last June awarded to Americans the concession to operate the manganese mines of Chiaturi, the most extensive deposits in the world. Competition was keen among international interests for this desirable award, which opens the way to an enlarged supply of manganese ore for the world's steel industry.

Manganese in some form is practically indispensable in the manufacture of steel, almost all of which contains it in certain proportions. In the production of ordinary steel by the Bessemer and open-hearth processes it is essential that a small amount of manganese be used and in making special manganese steels 10 to 12 per cent of manganese may be added. The functions of manganese in steel making are to serve as a deoxidizer and recarburizer and to impart essential qualities of toughness and hardness.

In the open-hearth process manganese is added in the form of ferromanganese and in making the higher carbon Bessemer steel as spiegeleisen, each of which is an alloy of manganese and iron. Low-grade ores containing from 10 to 35 per cent of manganese may be added directly in the smelting of pig iron without being previously converted into ferro-alloy. Normally the standard manganese content of ferromanganese ranges from 78 to 82 per cent, that of spiegeleisen 18 to 22 per cent and manganiferous pig iron contains from 4 to 10 per cent manganese. Accompanying the trend in steel making from the Bessemer to the open-hearth process demand for spiegeleisen yielded to more extensive use of ferromanganese.

Annual world requirements of manganese ore are estimated to be 1,750,000 tons. If the leaner ores are to be utilized a larger quantity would be required. More than 95 per cent of all manganese ore consumed in the United States is used by the steel industry. The remainder is used in the manufacture of dry batteries, glass, chemicals and to a certain extent in paints.

A half century ago iron was used principally in the form of cast or wrought iron which require no manganese. The discovery of manganese steel by Sir Robert Hadfield in 1883 gave tremendous impetus to the study of alloy steels. Other steel makers began research resulting in the discovery of a large number of additional alloy steels.

During the war the manganese situation was so acute that considerable sums were spent in developing manganese production particularly in the United States and Brazil. In the United States output increased from little more than 4,000 tons of ore in 1913 to more than 300,000 tons in 1918. High-grade manganese ore contains 35 per cent or more of manganese. The deposits of high-grade ore in this country are sufficient to meet only a small portion of normal domestic requirements. With the slump of 1921 output fell off to 13,000 tons. World iron and steel production declined and this resulted in smaller demand for manganese. In 1923 the iron and steel industry in this country reached record proportions. Again the probability of a manganese shortage arose. For the time being increased production in India and Russia provided necessary supplies although at high prices. Recent developments in the Russian fields promise to furnish the world with a normal supply.

Although manganese deposits occur in some form in many parts of the world, it is not economical, except in case of emergency, to work most of the deposits outside of Russia, India and Brazil which before the war produced 95 per cent of world supplies. Small quantities are shipped from Egypt, Cuba, Mexico, West Africa and Japan. Prospects appear favorable for increased supplies from the Gold Coast, British West Africa. There are possibilities of developing manganese mining in other countries but as yet the resources have been mostly speculative.

Open-cut manganese mines in India, among the world's most important.

Table A shows production in India, Russia, Brazil and the United States in 1913 and from 1918 to 1924. The United States is not a large producer but is included in the table to indicate the spectacular development of manganese mining in this country during the

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war. Under a protective tariff a little more than 56,000 tons was shipped from American mines last year.

Prewar output by the three chief producing countries Russia, India and Brazil was somewhat over 2,000,000 tons. The low point of production by these countries was reached in 1919 with a yield of but little more than 850,000 tons. There has been a steady gain in annual output since 1922 and production by the three countries in 1924 according to the best available estimates was 1,175,000 tons.

Manganese mining in India began in 1892. The peak production was reached fifteen years later when more than 900,000 tons was mined. Rapid expansion was due chiefly to the growth of the steel industry in the United States and Europe and in part to decline of manganese mining in Russia caused by political disturbances. For a brief period, from 1908 to 1911, India was the largest world producer but in 1912 Russia resumed the leading rank which was maintained until its foreign markets were cut off during the war. Fortunately for the world iron and steel industry, India, besides being one of the principal manganese producers, has served also as a balance wheel by maintaining or increasing output when Russian output declined or was cut off from international markets.

According to a survey by the British Imperial Institute in 1918 the richer Indian ores are becoming less plentiful. No discovery of new deposits has been made in recent years and many of the poorer deposits have been abandoned. Government restrictions relating to exploitation of manganese mining in certain areas by private enterprises were recently modified but even under the new regulations in addition to fixed royalties payable to the government the licensees are taxed to the extent of 25 per cent of net profits. Such a state of affairs is not conducive to increased production. Production in 1913 was 815,000 tons, the second highest in the history of Indian manganese mining. Output in 1915 declined to a low level of 450,000 tons largely on account of the inability to export during that year. Since the close of the war average annual production has been approximately 625,000 tons. Output is likely to fluctuate around this level. Annual production however is frequently affected by a favorable monsoon which draws a greater proportion of laborers to agriculture.

Brazil is of special importance to the American iron and steel industry because its total reserves of manganese are large and because for ten years after the beginning of the World War it was the chief source of supply for this country. For the five years from 1910 to 1914 Brazil furnished 24 per cent of United States imports, British India supplied 49 per cent and about 24 per cent came from Russia. For the period since 1915 Brazil has supplied almost 65 per cent of American imports, India about 13 per cent and Russia less than 10 per cent (including imports from Turkey in Europe).

Table B shows average annual imports of manganese ore into the United States by countries of origin for the five years 1910-14 and imports each year from 1915 to 1924. Imports of ferromanganese and spiegeleisen for the same period are shown in Table C.

While manganese from Brazil has been the mainstay of the American steel industry for the past ten years it is improbable that Brazil will continue to be as large a contributor as heretofore. Total exports from Brazil reached the peak of 524,000 tons in 1917. In 1924 only 157,000 tons were exported.

The more important deposits are far inland. Transportation facilities are poor and under normal conditions competition in manganese mining is so keen that ores from Russia and India can be sold in this country at a price on a par with South American manganese.

TABLE A—PRODUCTION OF HIGH GRADE MANGANESE ORE IN INDIA, RUSSIA, BRAZIL AND THE UNITED STATES IN 1913 AND FROM 1918 TO 1924

(In gross tons)

	1913	1918	1919	1920	1921	1922	1923	1924
India	815,047	517,953	534,995	736,434	679,282	474,397	695,055	*641,691
Russia†	1,207,380	413,357	75,211	95,459	†11,998	80,745	‡212,727	‡377,221
Brazil*	120,367	387,171	202,474	446,566	271,337	335,322	232,104	156,713
United States	4,048	305,869	54,957	94,420	13,531	13,404	31,500	56,515
Total (four countries)	2,146,842	1,624,350	876,637	1,372,879	†976,148	903,868	1,171,386	1,232,140

*Exports for the calendar year.

†Production of Georgia, former Russian territory, included except in 1921.

‡Production fiscal years October 1 to September 30.

TABLE B—IMPORTS OF MANGANESE ORE INTO THE UNITED STATES FROM 1910 TO 1924*

(In gross tons)

	1910-14† (5-yr. aver.)	1915†	1916†	1917†	1918	1919	1920	1921	1922*	1923*	1924*	1925* (6 mos. Jan.-June)
Brazil	62,104	121,155	409,605	541,043	345,871	246,592	421,523	262,468	319,171	183,408	114,454	73,119
British India	130,135	58,975	52,999	60,136	29,275	9,200	71,238	113,730	24,871	53,266	113,679	20,573
Russia	62,439	13,010	....	....	....	6,916	18,762	....	3,421	24,312	85,619	65,977
Turkey in Europe	....	....	....	....	....	2,000	1,000	....	28,644	79,456	109,494	....
Cuba	....	550	20,335	33,534	82,974	35,320	8,247	34	12 568	9,062	23,065	7,582
British West Africa	....	....	....	....	....	1,194	31,927	8,453	22,701	58,260	47,987	41,117
Other countries	9,344	13,169	9,921	21,375	33,177	32,122	54,240	16,669	13,693	11,685	10,836	14,472
Total	264,022	206,589	492,860	656,088	491,303	333,344	606,937	401,354	425,069	419,449	505,134	222,840

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*Under the Tariff of 1922 imports of manganese ore, except those from Cuba, are reported on the basis of metal content. Such imports are here converted into ore equivalent, assuming an average content of 48 per cent manganese.

†Fiscal years.

This situation is not to be deplored. The chief Brazilian deposits are under control of American interests. Although reserves available at present prices are not extensive, in the absence of domestic deposits adequate to supply the American steel industry over a long period, Brazil serves as a bulwark to protect the American steel industry from a shortage caused by possible political uprisings in Russia and India.

There are many extensive manganese deposits in Russia. Deposits in the district of Chiaturi, in the present Republic of Georgia, which before the war supplied three-fourths of the Russian output, are variously estimated at from 146,000,000 to 250,000,000 tons as compared with reserves of 11,137,000 in three most important districts of India and reserves of 10,000,000 tons in the largest active mine in Brazil. The manganese content of ordinary Caucasus ore is from 48 to 50 per cent which is considered high grade and resources of which are practically unlimited. At the normal rate of output the Chiaturi deposits are sufficient to last more than two centuries.

TABLE C—IMPORTS FOR CONSUMPTION OF FERROMANGANESE AND SPIEGELEISEN INTO THE UNITED STATES FROM 1910 TO 1924

Year	Ferromanganese (average manganese content 80 per cent) (In gross tons)	Spiegeleisen (average manganese content 20 per cent) (In gross tons)
1910-14 average	102,188	12,936
1915*	66,837	1,244
1916*	82,604	†
1917*	69,109	†
1918	26,906	1,969
1919	33,022	27
1920	59,254	5,234
1921	9,077	307
1922	‡100,617	‡25,159
1923	‡113,833	‡23,495
1924§	¶	¶

*Fiscal years.

†Not reported separately.

‡Metal content shown in import statistics since September 21, 1922 has been converted to same basis as preceding figures.

§All figures in this table are imports for consumption except 1924, for which general imports are given.

¶Manganese content of ferromanganese and spiegeleisen imported in 1924 was 47,922 tons.

Production of manganese ore in Russia in 1913 was 1,207,000 tons. The effect of war and internal political upheaval reduced the output in Russia exclusive of Georgia to less than 12,000 tons in 1921 when apparently the mines in Georgia were not operating. Since that year production has increased steadily and according to a report published recently in the "Russian Review," output for the fiscal year ended October 1, 1924 was about 400,000 tons. Accumulated stocks of ore at the mines on October 1, 1924 were only 221,000 tons against 371,000 tons a year previous.

Partly as a result of lack of progress under soviet management a 20-year mining concession was granted in June to American interests to operate the manganese mines in Chiaturi. The new organization with the co-operation of large European consumers proposes to consolidate the numerous small holdings and reorganize completely methods of production along modern lines. According to recent reports over 100,000 tons of Russian ore have been sold by the American concessianaire for shipment to the United States over the balance of the current year. Development of proposed adequate transportation facilities in the Russian fields will have farreaching effects toward restoring the Russian manganese industry to its former status. Successful development of Russian fields will be necessary before a normal supply of manganese will be availbale for the world markets.—Commerce Monthly.

Sir Robert Hadfield in Paris

Early in October last, Sir Robert Hadfield attended the Cinquieme Congres de Chimie Industrielle, held in Paris, and there read an address entitled: "Part I—Some Notes with Reference to the Author's Association with French Metallurgy (1889-1925) and the Important Part Played by France in the Past. Part II—Some Curious and Unexplained Facts Connected with Manganese Steel."

This address was received with much cordiality, and after it was read the president of the congress, M. Dior, got up and made some pleasing comments upon it, also as regards the work Sir Robert and Lady Hadfield had done in their hospital at Boulogne during the war, through which passed some 16,000 cases, including both British and French soldiers. M. Dior also announced that the Council of the Societe de Chimie Industrielle had conferred upon Sir Robert the honorary membership of that body.

In concluding his address Sir Robert said:

"That which was true of the past centuries is still true of the present day. Paris has not lost her ancient renown in the sciences; she still preserves it, and it may very frequently be observed that the great ideas which spread throughout the world of science are ideas the origin of which may often be traced to distinguished Frenchmen.

"I venture to believe that in uttering these sentiments I am expressing, not my own views alone, but those of my colleagues here present, and those, indeed, of the whole world. I trust that France will maintain, in the future, the position which the wisdom of her great men has won for her in the past.

"We all hope that peace will crown the noble and heroic efforts which were put forward during the great war, efforts which France sustained her share, in the service of humanity and for the high cause of liberty and justice."

In recognition of Sir Robert's great services to the science of metallurgy, the French government, under M. Painleve's administration, recently decided to confer upon him the high distinction of "La Croix de l'Officier de Legion d'Honneur."

The insignia of the order was presented to Sir Robert by the French ambassador on New Year's Day. His excellency was kind enough not only to present the Cross, but to give Sir Robert his own "baton rouge" as he is a member of the same order, this being the usual indication worn on ordinary morning dress by those who have received this honor.

Mr. E. H. Haslam, of Bucyrus, Ohio, president and general manager of the Hadfield-Penfield Steel Company, was fortunately present on New Year's Day when this honor was conferred upon Sir Robert.

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By E. H. McCLELLAND*

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French Iron and Steel in 1925

A most interesting account of the French iron and steel trade during 1925 is just to hand from Paris. It states that the instability of the franc was the principal factor that influenced the industries during the year. There was, however, no lack of coke, and the production of iron and steel increased. In export trade generally good business was done, but at home the market remained quiet during the greater part of the year and kept stable only by reason of the agreements concluded among the producers. Its course would certainly have been far more disturbed by the political and financial uncertainty which prevailed almost throughout the year, and by the fluctuations of the franc, if producers had not realized the necessity of presenting a united front and fixing minimum prices in each section. Another result of the fall in the franc was an advance in the cost of living and in the general expenses of manufacture.

Iron and steel production increased without doubt, but not to the extent that is usually believed. During the 11 months the average monthly output of pig iron was 712,000 tons, and of steel 614,000 tons, against the preceding year's figures of 635,000 tons of pig iron, and 572,000 tons of steel. Although supplies of coke were sufficient, its price remained high, varying from 138.75f in January to 145.95f in June and 142.25f in December. Home demands have not been at such a level as to necessitate any great effort on the part of producers, and the output has been considerably below capacity. For example, the number of blast furnaces in activity on December 1 was only 145 out of a total of 219; the figure on January 1, 1925, was 133.

The report states that at the time it was prepared, foreign trade figures were only available for the first 11 months of the year. These show imports of pig iron totalling approximately 30,000 tons, or 10,000 tons more than in 1924, and exports of 612,000 tons, against 676,000 tons in the preceding year. It must be remembered that in 1924 the figures included 102,000 tons exported to the Saar, which now forms a part of the French Customs Union.

Of ferro-alloys, nearly 17,000 tons were imported, against 11,000 tons in the corresponding 11 months of the previous year, while exports were less than 4,000 tons as compared with over 16,000 tons, thus showing a greatly increased consumption within the country. Substantial increases are shown in exports of manufactured iron and steel, their total having been about 3,000,000 tons or 30 per cent more than the preceding year. At the same time imports were only about 130,000 tons, as against 643,000 tons. Shipments to Great Britain during the 11 months are as follows:

	1924 in tons	1925
Iron ore	548,000	199,000
Pig iron	88,000	125,000
Blooms, billets and bars	311,000	415,000
Rails	44,000	17,000

The mining of iron ore did not increase to the extent desired to meet the demands of home and export trade, consequently there was a decline in foreign sales. At the same time Belgium, owing to a partial stoppage for six months, consumed less French ore than usual. Prices advanced, but only slightly.

The year witnessed the reconstitution of the producers' ententes, and although at the present only that of the pig iron makers is officially in existence, the rail workers are on the eve of forming a syndicate and steady work is being done in reviving the steel makers' agreement.

The O. S. P. M., which represents the producers of pig iron, semi-products, joists, hoops, and merchant steel, commenced its operations in the spring, but did no more at first than fix minimum basis prices and conditions of sale. Its period of operation, which was to have terminated on June 30, was prolonged for three months in order that efforts might be made to arrange agreements on a new basis. Subsequently the producers of phosphoric pig, hematite, and spiegel came to an arrangement regarding not only basis prices, but also the apportionment of home orders. An attempt has been made to bring about a similar understanding among steel makers, but although such a course is generally considered desirable, complete agreement has not yet been reached owing to difficulties arising from the fact that their number is large and their interests very varied. Some supply only the home market, others are only partially engaged in export trade, while several deal specially with foreign business. If business had been less active, this entente would probably have been successfully formed.

Prices of foundry pig No. 3 P. L. were maintained at 345f between April and December, and have risen since to 367f, or for supplementary quantities to be supplied in January and February to 395f. Quotations for semi-products and rolled steel rose slightly when the agreement was concluded, remained stable for about six months, i. e., while the agreement remained in force, but weakened slightly in October. Competition among the producers reappeared in the autumn, and since November there has been a noticeable advance in bars. French importations of sheets have been very restricted, while exports have grown substantially. This increase is attributed not only to the depreciation of the franc, but also to the action of the producers' entente.

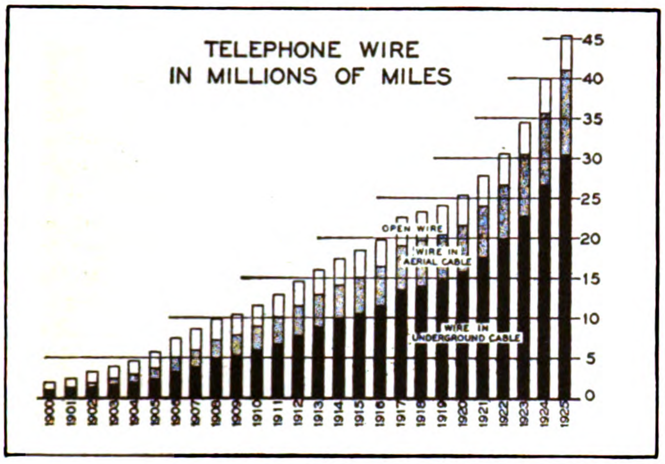
The French makers had to reckon with the competition of Belgium during the first half of the year, i. e., until the strike occurred at Charleroi and the Belgian franc dissociated itself from the French. The Luxembourg firms, thanks to their splendid organization, rapidly filled their order books and virtually retired from the market. The Germans were frequently required to liquidate at extremely low prices stocks of semi-products, sheets and machine wire in order to procure capital, and consequently considerably weakened the market.

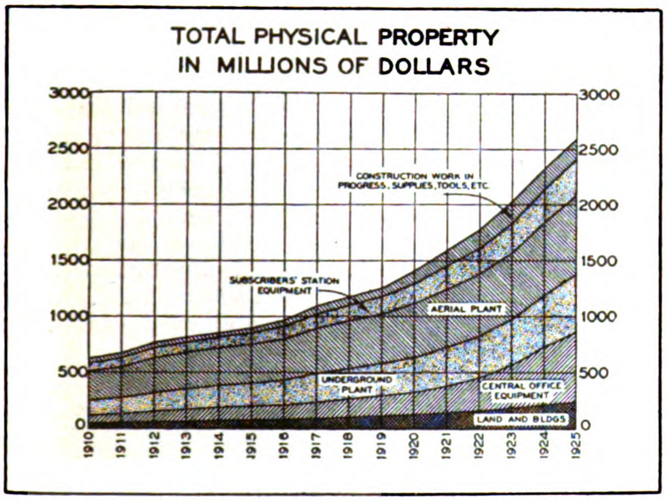
The condition of the French exporters substantially improved at the end of October, when the franc began to fall rapidly, although at the same time buyers displayed some uneasiness regarding the future trend of quotations. Their principal customers were Great Britain, Italy, Germany, and Switzerland for pig iron and semi-products, with the addition of Japan for rails, and next in order of importance Holland, Brazil, and the Argentine.

At present the activity of the market seems purely artificial. Purchases on home account are going into stock, and, as consumption is at a low level, it is felt that the market during the current year will be dull.

Telephone Growth

Progress in the quality and extent of telephone service is the keynote in the annual report of President W. S. Gifford, of the American Telephone & Telegraph Company. He states that more than 813,000 telephones were added to the Bell System during 1925. At the end of the year 16,720,000 telephones were interconnected so that practically any one of them can be connected with any other one throughout the United States, at any time, day or night. Over 50,000,000 toll and exchange connections, each an individual transaction, are handled daily.





$365,000,000 was expended by the Bell System on new plant construction, including new plant to replace $107,000,000 of plant retired. Net additions to plant were $258,000,000. This brought the assets devoted to furnishing telephone service up to $2,938,000,000. The number of persons employed, including those in the Western Electric Company, was over 332,000.

The gross revenue of the Bell System, he states, was $761,200,000, and net earnings were 6½ per cent on the amount invested in plant and other assets. Earnings available for contingencies and surplus amounted to 1-1/3 per cent on the investment—less than a cent a day a telephone, a necessary but relatively small margin of safety.

It is shown that there were over 362,000 stockholders of the American Telephone & Telegraph Company at the end of the year, making the Bell System in a sense, publicly owned. The amount of capital stock of the American Company outstanding was $921,597,500, an increase of $33,119,400 for the year.

The net income of the American Telephone & Telegraph Company was $107,405,000. Of the resulting balance, after payment of dividends at $9.00 a share, $6,000,000 was appropriated for contingencies and the remander, $20,360,000, was carried to surplus.

Mr. Gifford says that the nature of the business requires a nationwide organization operating under state laws and state regulation and federal laws and federal regulation. This requires various intercorporate relations, which, however, are simple in principle and not arbitrary. It comprises in brief the American Telephone & Telegraph Company, which is the parent company, 25 Associated Telephone Companies, and the Western Eelectric Company, and the report shows the necessary functions of each.

Mr. Gifford says that although the Bell System is growing larger and more complicated, it is less hazardous to manage because of a better knowledge of the essential facts. He says that the population of the country grows at the rate of from one to two per cent a year, general business at the rate of three or four per cent, and the telephone business, due to the higher standards of living and the trend toward the economy of time, increases at a more rapid rate than general business.

Telephone service is not a commodity, he says, or a physical product comparable to that furnished by other industries, or even other utilities.

The problem of furnishing service increases with the number of telephones interconnected and except for ecenomies, many factors of cost would increase greatly. Telephone costs have been kept at the present low point in spite of the unique character of the business, only by constant invention and development of new types of apparatus and by new and better methods of operation.

During the past year steady improvement has been made in telephone service so that it will better meet the requirements of the users. Maintenance and upkeep have been continued on a high plane, with strict attention also to all possible economies. The amount of new construction for 1926 is expected to be somewhat greater than last year.

Mr. Gifford speaks of the continuing work of development and research on more than a thousand problems relating to telephone service, on continuing experiments in transoceanic telephony, and on other phases of radio transmission which might have application in the extension of telephone facilities.

The result of improvements and economies is apparent, he says, in the cost of telephone service to the public. Telephone rates are, on the average, only 33 per cent higher than ten years ago while wages and material costs have increased much more and living costs have increased 75 per cent. Bell System companies do not need nor do they seek to earn more than a reasonable return on their property. Rate adjustments have been made necessary chiefly because of the change in the value of the dollar.

Speaking of relations with the public, Mr. Gifford states that in the telephone business they are founded on satisfactory service at the lowest possible rates. This is the aim of the Bell System. It also aims to conduct its affairs in accordance with American ideals and traditions.—Annual Report.

Employes Receive Recognition for Outsanding Contributions to Industry

Thirty employes of the General Electric Company, scattered through factories and offices all over the United States, have been given awards in recognition of outstanding performances in 1925. The awards include Charles A. Coffin Foundation Certificates of Merit and honorariums of $300.

More than half of the awards went to members of the factory group. These men, only a handful out of more than 50,000 engaged in the company's manufacturing organization, made worthwhile suggestions that revolutionized the processes on which they were engaged—suggestions that could not be expected from them as part of the work in which they were engaged. They invented new machines, developed new manufacturing processes, reduced production costs, increased output, and bettered working conditions. It was in recognition of these services in addition to their regular work which entitled the men to the awards.

Henry Klammer, a repair man in the induction motor department at Schenectady, who has been employed by the company 23 years, received his award as the second recognition of his outstanding service in the design of a pull-out coil for winding induction motor coils. Its adoption made possible the winding of coils by machinery, an operation previously done manually. Its use has increased the output at a reduced unit cost. Mr. Klammer was previously awarded $500 by the suggestion committee for this work.

Three other workmen likewise received Coffin awards as additional recognition of their work in the past year. Raymond Z. Woluns, a winder in the Windsor Works, had previously received $275 from the suggestion committee for his new method of insulating the bi-polar type of machine-wound armatures, whereby time was saved, costs reduced, and product improved. Alexander Iwanowicz, a wire insulator in the Pittsfield Works, and Frank L. Coombs, a machine operator in the wire and insulation department of the River Works at Lynn, had each previously received $100 from the suggestion committee. Mr. Iwanowicz devised a spiral method of applying cotton insulation to small sizes of wire, and Mr. Coombs improved the apparatus for treating canvas duck with bakelite, greatly increasing production with added economies.

Three awards were given to Marvin Pipkin, Alfred N. Burchard and Kenneth A. Reider of the incandescent lamp division at Cleveland for the invention and perfection of apparatus for the manufacture of the new type inside-frosted incandescent lamp. This lamp gives more light than the outside-frosted type, is more rugged in construction, and costs less.

C. W. Place of the Chicago office spent his vacation in the Wisconsin woods, in a map-making and investigation tour. The result was a report of the hydroelectric possibilities of the region, so complete that a public utility company is using it as the basis for a large power development, of which one unit is already completed.

Those receiving the Coffin awards include eight shop workers, eight foremen, eight engineers, five commercial men, and one in the administrative department. Geographically, the awards include six at Schenectady, four at the Cleveland lamp works, three at both Lynn and Pittsfield, two at the Harrison lamp and Niles glass works and the Fort Wayne works, and one at Windsor works. Chicago office employes received two, and the Dallas, San Francisco and Providence offices one each.

The Charles A. Coffin Foundation was established by the General Electric Company in 1922 as a tribute to Mr. Coffin, one of the founders and for a long time president of the company. In addition to those already mentioned, the following received the 1925 awards:

Shop Men.

Charles W. Craig, machinist, Cleveland incandescent lamp works. Designed and constructed with Frank B. Van Sickle water-cooled gathering ram for use with bulb machine.

Frank B. Van Sickle, Cleveland incandescent lamp works. Designed and constructed, with Charles W. Craig, a water-cooled gathering ram for use with bulb machine.

Michael McGowan, mechanic, Harrison incandescent works. Developed method for holding mica discs in higher wattage lamps.

Foremen.

August Kayser, tool designer, Fort Wayne works. Designed very special and highly automatic machines for completely machining meter bases.

Thomas McGuckin, construction foreman, light, heat and power department, Schenectady. Designed and developed set of fixtures for factory wiring installations.

Joseph W. Kessler, general foreman, molded insulation department, Pittsfield. Increased the output of his department by approximately 60 per cent because of increased efficiency following a general economy in manufacturing processes.

Rudolph Hillner, foreman, turbine department, Schenectady. Developed fixtures for milling turbine parts, resulting in improved products at lower costs; also developed fixtures which simplified and speeded production of radio parts.

John F. Heath, foreman, motor department, Schenectady. Developed method for use of straight bar construction in some sizes of wound rotors for induction motors.

Dennis F. Madden, foreman, searchlight department, Schenectady. Developed and put into effect numerous improved manufacturing methods.

Helge E. Carlson, foreman, street lighting department, River Works, Lynn. Developed coil-winding machine which has resulted in greatly increased production with one-half the floor space and equipment formerly used in manufacture of Tungar rectifiers.

Engineers.

Svend Johannesen, developmental engineer, Pittsfield. Redesigned distribution transformers and developed winding machine and special tools for their production.

Walter W. Brown, engineer, Erie works. Improved method of manufacturing controller parts.

Peter P. Alexander, research worker, Thomson Research Laboratory, River Works, Lynn. Developed method for producing ductile arc weld.

(Concluded on page 199)

Commutation Troubles in D. C. Motors

There Are Several Sorts of Commutation Troubles in Both Motors and Generators—Professor Stavely Clearly Describes Their Causes and Remedies

By EARL B. STAVELY*

THE most common operating troubles associated with the application of d.c. motors and generators are due to poor commutation, that is, to sparking at the brushes. This article is the first of a series in which the writer discusses methods which may be employed in eliminating sparking troubles in d.c. dynamo machinery.

This article, which is the first of a series dealing with commutation troubles in direct current motors, should be of interest due to the rapidly increasing use of individual motor drives. This is particularly true in the iron and steel producing industries because of the severe conditions under which motors operate, such as excessive heat, dust, grit and corrosive fumes. These articles will also include a discussion of the causes of sparking, the remedies to be applied, the care of brushes and commutators, and the application of different types of brushes.

Sparking at the brushes always indicates that the brushes and commutator are not functioning properly. This sparking not only increases the cost of maintenance of brushes and commutator, but frequently leads to complete failure of the commutator and armature winding. It is also important to note that practically every defect in a d.c. machine causes sparking of more or less severity. These defects may be due to faulty design or manufacture, but most frequently result from improper conditions of operation or from failure to maintain the machine in good operating condition. A sparking machine should always be considered as a "sick" machine which should be given immediate attention. Careful attention should be given to such machines even though the sparking does not appear to be of a serious character, since comparatively slight sparking may lead to more severe sparking which is difficult to eliminate.

Basic Causes of Sparking.

As stated previously, sparking indicates that the brushes and commutator are not functioning properly. It will be well, therefore, to review briefly the functions of these parts of the machine.

One function of these parts is to provide a suitable electrical connection between the line and the rotating armature. Such connection is provided only if the commutator and brushes are both in proper condition, and if proper contact between brushes and commutator is maintained while the machine is in operation. Poor contact between brushes and commutator always causes sparkng since current passing across a poor contact of any kind in an electric circuit always produces excessive heating and arcing of more or less severity. Poor contact between brushes and commutator results most frequently from the condition of the commutator face, the brush, or the brush holder, but may also result from certain external causes.

A second function of the brushes and the commutator is to "commutate" the coils of the armature winding. As a coil passes from the influence of one field pole to that of the next pole, which is of the opposite polarity, the direction of induced voltage and current reverse in that coil. If no commutator were provided an alternating current would be supplied to the line. The brush and commutator reverse the connection of each coil to the line at the same time that the direction of the induced voltage and current reverse in that coil, hence a direct current is supplied to the line. During a short interval of time (that required for a commutator bar to pass the brush) the current in the coil being commutated must, therefore, be changed from normal value in one direction to normal value in the opposite direction. Sparking at the brush will result in case this reversal of the current is seriously interfered with by any cause. During this period of commutation the coil is also short circuited by the brush and, under certain conditions, excessive local currents may flow in the short circuited coil and these local currents may lead to serious sparking.

Method of Treatment.

A sparking motor may be compared with a person who is found to have a high fever. The sparking, just like the fever, may be due to a very simple cause, but may also be due to a number of very serious and complicated causes. A reputable physician does not employ "cut and try" methods in the treatment of a patient. He carefully studies the symptoms shown by the patient and closely observes the effects of the remedies he uses.

The same method of procedure should be followed in attempting to eliminate the sparking of a motor or generator. Cut and try methods are costly in most cases since their use involves the expenditure of considerable time and labor, and there is always the possibility that the machine may fail completely before the cause of the sparking is determined and eliminated.

A careful study of the symptoms shown by a sparking machine usually makes it possible to determine the cause of the trouble in a comparatively short time. Once the cause is determined, the elimination of the trouble is usually a rather simple matter.

Throughout this series of articles considerable attention will be given, therefore, to the various symptoms shown by sparking machines, and to the manner in which the cause of the trouble may be determined by an analysis of these symptoms. A discussion of the more common causes of sparking will be included since a knowledge of these causes is required in the solution of sparking problems. The remedies in each case will also be indicated.

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General Symptoms.

Before proceeding further it may be well to note briefly the character of the symptoms with which it is necessary to deal when attempting to treat a machine which is "sick" due to sparking.

The character of the sparking is in itself a symptom which often points directly to the cause of the trouble. The color and size of the sparks, the number of sparks and their distribution at the brush contact, the variation in sparking as load conditions change, and similar details are symptoms which should be carefully noted.

The appearance of the commutator is another important symptom. General burning and blackening of the commutator face, local burning at certain bars or groups of bars, pitting of the mica between bars, grooving of the commutator, etc., are symptoms which indicate rather definite causes of sparking.

The appearance of the brush face is another item which should be carefully noted. The face may be burned or pitted over its entire area, or only over certain parts. A deposit of copper may be found on the brush face. The edges may be burned badly while the remainder of the face appears to be in good condition.

The condition of the brush holders, the behavior of the brushes at different speeds, variation in character and amount of sparking at different brush studs or at different brushes on the same stud, and noise caused by the brushes are other factors which should be noted in the search for symptoms.

The "sparking history" of a machine is usually of considerable assistance in solving sparking problems, just as a knowledge of the previous physical condition of a patient may greatly assist a physician in discovering the cause of an affliction.

This somewhat lengthly introduction has been included in this article in order to stress the importance of a study and analysis of symptoms. In most of the literature available to the man in the field there are given tables, etc., outlining the causes and remedies which may be considered in attempting to eliminate sparking troubles. Little information is given, however, relative to methods which may be employed in determining the cause itself. The purpose of these articles is to "fill the gap" in this information by discussing the symptoms and the analysis of these in the solution of sparking troubles. The more simple symptoms will be discussed first; more complex symptoms will be considered in following articles.

Reddish-Brown Sparks.

Sparks of this color, while quite variable in character, always point directly to dirt, that is, to the presence of a film of oil, grease, dust and other foreign material on the commutator which is interfering with the flow of current across the contact between brush and commutator.

While this film of dirt is composed of conducting materials, its electrical resistance is so high that sufficient heat is produced by current flow through the film to ignite particles of the dirt. The physical nature of the dirt is such that its burning under these conditions produces the characterisic reddish-brown color of the sparks. The burning of the dirt also causes the commutator to have a dirty black color—a symptom which suggests the presence of an undesirable amount of dirt even though the sparking may not appear to be serious.

Reddish-Brown Streamers.

Streamers of reddish-brown fire extending for some distance along the commutator in the direction of rotation, as shown in Fig. 1, indicate the presence of a very considerable amount of dirt. In this case the sparking under and near the brush produces hot gases which are carried along the surface of the commutator by its rotation, and the burning of these gases and of the dirt on the commutator produces the streamers of fire just mentioned.

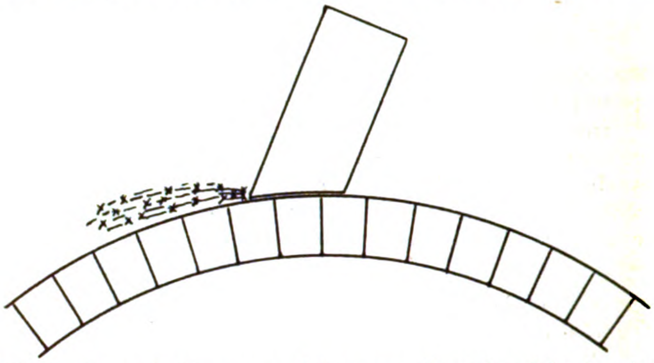

FIG. 1—*General appearance of "streamers" produced by burning of dirt on face of commutator. These are of a reddish-brown color and the commutator assumes a dirty black color.*

Ring Fire.

Ring fire indicates the presence of an excessive amount of dirt, the burning of which may produce sufficient heat to cause failure of the commutator and armature winding. In this case so much heat and hot gas is formed that the dirt around the entire commutator is ignited and a ring of reddish-brown fire, as shown in Fig. 2, is produced. Ring fire commonly results when the slots between bars of commutators having undercut mica are allowed to become filled with dirt.

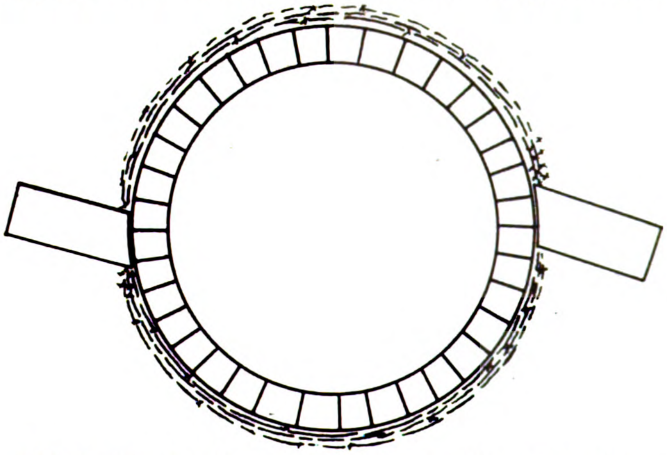

FIG. 2—*Ring fire, if of a reddish-brown color, is caused by the burning of dirt on a very dirty commutator.*

Intermittent Ring Fire.

It is found, in many cases, that the streamers or ring fire of the type just described occur for a few moments and then disappear, but that this condition is repeated at intervals. This is due to the fact that the amount of dirt present is sufficient only to cause

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such sparking over a short interval of time, the sparking ceasing as soon as the dirt has been burned away and then occurring again after dirt has again collected on the commutator.

Bluish-White Sparks.

Very vicious sparks of this color, accompanied by a sharp cracking noise, occur when open circuits are present in armature coils or when there are very high resistance contacts between coils and bars.

The most common sparks of a bluish-white color are produced by arcing between brush and commutator, that is, to the current jumping across gaps between brush and commutator. Such gaps are generally due to poor contact between brush and commutator or to conditions which cause the brush to move away from the commutator, and thus break the circuit, at intervals.

Sparks of this color are usually associated with another symptom of this same trouble—a commutator with a burned appearance of a clean black color rather than of a dirty black color.

Sparking of this type is usually associated with certain other symptoms which will be considered in the following paragraphs.

Portion of Brush Face Burned.

This symptom, when associated with bluish-white sparks and a burned commutator, commonly indicates poor brush fit, although other causes which will be discussed later may produce the same result. If the brush is not sanded properly it may make contact with the commutator only at part of its face, as shown in Fig. 3. In this case the actual area of contact may be only a small fraction of the area presented by a properly sanded brush, hence the current density at the portion in contact with the commutator may be many times the maximum safe operating density, and burning of this portion of the brush then results. The contact is, of course, made worse by this burning and the arcing of current across this poor contact results in the formation of bluish-white sparks.

The box of the brush holder may be badly worn or burned, or the brush may be too small, in which case considerable rocking of the brush in the box is possible. This may result in the brush being forced out of good contact with the commutator by the rotation of the commutator as shown in Fig. 4. A similar result is often found when the brush is too long, the spring of the holder exerting a force on the brush in such direction that the area of contact between brush and commutator is considerably reduced in case the brush does not fit tightly in the box. (See Fig. 5.)

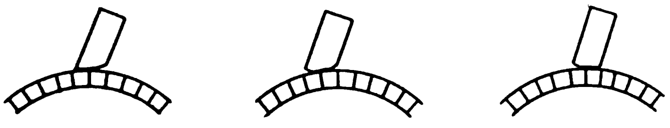

FIG. 3—*General types of poor brush contact resulting from improper sanding of brushes. Bluish-white sparks, a blackened commutator, and the burning of a portion of the brush face are symptoms of this cause of sparking.*

Entire Face of Brush Burned.

This symptom, when associated with bluish-white sparks and a burned commutator, indicates that sparking is occurring over the entire contact between brush and commutator. This trouble results from a variety of causes, each of which is characterized by rather definite symptoms. The more common of these associated symptoms will be discussed here; more complex symptoms and causes will be considered in a following article.

Brush Chatter.

When chattering of the brushes occurs the contact between brush and commutator is repeatedly broken and closed at a rapid rate, sparking resulting each time the brush leaves the commutator face. These sparks have a bluish-white color if no dirt is present. The peculiar noise associated with brush chatter is a symptom which should at once be recognized.

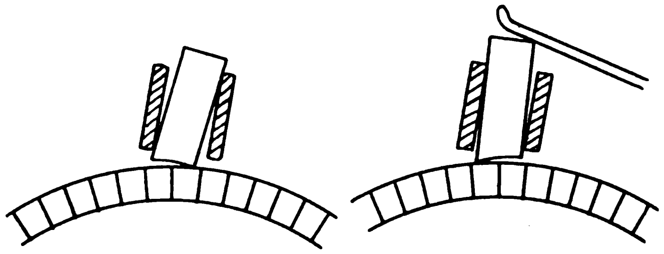

FIG. 4—*Poor contact resulting when brush is too small for box of holder. Symptoms—Portion of brush burned, bluish-white sparks, and blackened commutator.*

FIG. 5—*Poor contact due to pressure of spring on brush which is too long and too small for box.*

Chattering of the brushes is produced by purely mechanical causes. Excessive vibration of the machine usually causes considerable brush chatter. This may be eliminated in part by increasing the spring tension on the brush, but the proper procedure is to eliminate the cause of the vibration of the machine.

Chattering will also result if the spring tension is too low or the brush is too short, and especially so in case the commutator is slightly rough or there is an appreciable vibration of the machine.

Hard brushes show a marked tendency to chatter in case the commutator face is quite dry or in case the brushes are set in a stubbing position with respect to the commutator face. Improper undercutting of mica will also tend to produce chattering. Other causes will be noted later.

A careful examination of the machine, both while in operation and while at rest, will usually disclose the cause of the brush chatter.

High Mica.

High mica, or mica projecting above the commutator bars, is a symptom which may be readily detected by an examination of the commutator. Sparking of any kind causes a burning of the copper of the bars, but not of the mica between bars. If the commutator is not under cut, this burning of the copper may soon lead to the condition where the copper is burned away faster than the mica is worn down by brush. This causes the mica to project above the bars, in which case it is impossible for the brush to make good contact with the bars, as shown in Fig. 6, and more severe sparking then results due to this poor contact. The action here is cumulative, the sparking and burning of the copper becoming worse and worse.

The cause of the trouble may be eliminated in certain cases by the use of a hard brush, of high abrasive

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qualities, which will wear down the mica at the same rate as the copper is burned away. This, of course, is a makeshift remedy. Brushes of this kind show a marked tendency to chatter and their lack of lubricating qualities results in high friction losses and heating at the commutator. Temporary relief can be secured by turning down the commutator, but high mica will soon result unless the sparking is eliminated. In case it appears impossible to eliminate the sparking, undercutting the mica is the only remedy which will lead to satisfactory results. Undercutting of mica will be discussed in some detail in a following article.

Grooving of Commutator.

In some cases grooving of the commutator is due to the use of brushes of high abrasive qualities which cause a rapid wearing away of the commutator.

In other cases it is found that grooving of the commutator occurs in a machine which sparks under certain conditions of operation, but that the commutator has a clean appearance and shows no signs of burning or of high mica. These symptoms most commonly occur in machines which are operated for a certain length of time under conditions which cause sparking (severe overload, for example) and then operated for a longer period under light load. Under such conditions it is possible for the bars to become burned during the overload after which, during the period of light load, little sparking occurs and the brush wears down the mica to the level of the bars and also wears away the burned surface of the bars. This action results in a clean commutator which shows grooves.

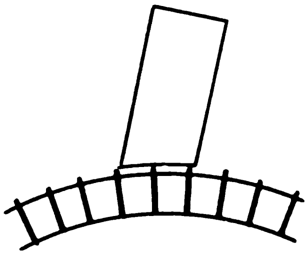

FIG. 6—*High mica prevents brush from making contact with commutator bars. Symptoms—Bluish-white sparks, blackened barrs, brush burned over entire face, high mica can be noted by touch.*

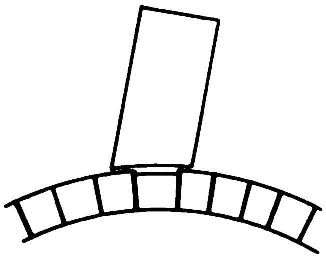

FIG. 7—*A low bar cannot make contact with the brush. Symptoms—Bluish-white sparks, brush face burned, low bar burned and blackened.*

Blackening of Individual Bars.

This symptom is frequently associated with bluish-white sparks, a burned brush face, and a certain amount of noise which is similar to that produced by brush chatter. These symptoms indicate that the brush is forced out of contact with the commutator each time the blackened bar, or bars adjacent to it, pass the brush. This effect may be produced by a variety of causes.

A low bar will be thus blackened since the brush usually spans more than one bar, hence the brush cannot possibly make good contact with this bar, as shown in Fig. 7. Arcing results, therefore, between the brush and this bar each time the bar passes the brush and the bar becomes badly burned and is thus given a blackened color. Flat spots, consisting of a small group of low bars, will cause the same type of sparking and will be similarly blackened.

A high bar will throw the brush away from the commutator each time it strikes the brush and an arc will result which will cause burning and blackening of this bar. A high bar also causes, in most cases, chipping of the brush for reasons which should be obvious. In many cases a high bar causes blackening of several bars adjacent to it, in addition to blackening of the high bar itself, this being due to the fact that the brush, after being forced from the commutator by the high bar, does not return to the commutator before these bars come under the brush. This result will be quite marked in case the brush is sluggish in following the commutator due, for example, to the brush having a tendency to stick in the holder on account of the presence of an excessive amount of dirt in the brush box.

A loose bar will produce the same effects as a high bar, since sufficient force is usually developed on the bar by the rotation of the armature to cause this bar to rise above the surface of the commutator. Careful examination is often required in detecting the presence of a loose bar since such bars have a tendency to return to their normal position when the machine is shut down.

An eccentric commutator may cause the brush to be thrown from the commutator each time the high side passes the brush. This result is found most frequently in machines having commutators of small diameters and which are operated at high speed.

A bad splice in a belt, a poorly made belt lacing, slipping of a belt, a broken gear, and a pound of some kind in the driven machine are other factors which frequently cause the brush to be thrown from the commutator at intervals. The symptom usually associated with these causes of trouble is that of a commutator which shows a number of burned spots rather than the burning of bars at only one point. This results from the fact that a bad belt splice, for example, will first strike the pulley when one bar is under the brush and then strike the pulley when another bar is under the brush. The relative location of the burned bars will then be determined by the length of the belt and the diameter of the pulley, one machine showing two or more burned spots almost equally spaced, another showing but two such spots quite close together, and so on.

Pitting of Mica.

Burned spots in the mica between certain bars is a symptom which is usually associated with sparking which takes the form of a thin ring of fire surrounding the commutator, this being somewhat similar to the ring fire previously mentioned, but usually of a yellowish-red color.

The piting or burning of the mica is generally due to the presence of oil or grease which enters the mica plate by dissolving some of the binder used in sticking together the flakes of mica in forming the plate. The oil in this case carries with it a certain amount of carbon and copper dust produced by the wearing away of the brush and commutator bars. This dust, together with other dirt or foreign material, forms partial short circuits between bars and the heat produced by the burning of this material causes burning or pitting of the mica. The rapid rotation of but one such burning spot makes it appear to an observer that a thin ring of fire is surrounding the commutator.

(Continued on page 196)

The POWER PLANT

Visualized Boiler Operation

Just What Constitutes the Essentials of a Modern Steam Plant Is a Problem of Major Importance

By **JOHN D. HILES***

IT is difficult for a boiler plant operator to get the best results without having the several parts of the boiler operation visualized. Ordinarily, there is nothing but the steam gauge and not even a colored glass through which the operator can view the fire conditions.

Boiler plant operation is becoming a science and each boiler should be equipped so that practically a continuous boiler test would be the result of every day operation. Each point in the boiler, or part of the boiler which is responsible for the proper operation, or may represent physical defects, etc., should be properly visualized to the operator. It is just as necessary for the boiler operator to have instruments as it is for the medical doctor to have instruments. It will hardly be gainsaid that more confidence is in the medical doctor who does use the necessary instruments to determine the internal conditions of the human body than the medical doctor who does not; therefore, more confidence will be imposed in the boiler plant operator when his operation is assisted by the use of the proper instruments. Visualizing the boiler plant merely indicates or records its operation, but does not correct any improper operation any more than the indicating instrument of a medical doctor, which only indicates the internal conditions, would correct the trouble without the application of the proper remedy. However, from such visualizing of the boiler operation, the most common kind of an operator can be educated to get more economical results.

There are five important points for visualization, the results of which can be co-ordinated by the operator. The following items are not named in the order of their importance as it would be most difficult to say which item is the most important. They all are important:

1—Feed water meter, which measures the input of water. This meter should be indicating, recording and integrating. In some plants it might be advisable to have a boiler meter for each individual boiler, but in the general run of the smaller industrial plants one feed water meter in the main line discharge would be sufficient and would give the overall water input. Frequently, when each boiler is to be equipped with steam flow meters, the water meter seems to be, in the estimation of some, unnecessary; however, the difference between the total input of water and total output of steam is information well worth having.

2—Steam flow meter, which measures the output of steam, should be indicating, recording and integrating. Preferably a meter for each boiler, as it will indicate whether each boiler is doing its proportion of the work. If a boiler is not doing its proportion, and cannot be made to do so, it is a sure indication that the boiler is not performing properly and should be taken off the line and inspected and repaired. It may be the means of taking the boiler off the line in time to prevent some major repairs or accidents that will be very costly and the price of the meters would be quickly justified.

As stated, these meters should be indicating, recording and integrating. The chart will give a permanent record of the operation and tells the story to the chief engineer who may see it only from time to time. It will enable him to compare the operation of boiler per boiler and possibly find some troubles that the operator did not catch, and the chief engineer can suggest remedies therefor.

3—The draft at various places is to be considered under this item and as one item, although there are several places where the draft should be taken. The draft over the fire is very essential and the proper draft gauge should be used. If the plant is forced draft, then a wind duct gauge should also be installed. These two gauges would indicate the conditions under which you are operating and are very vital, as the wind for combustion is the primary and essential element for the proper combustion. Another draft gauge, showing the draft in the last pass, or the differential draft between the first and last passes, is desirable, but not so necessary as the draft over the fire. The draft through the boiler is merely a conveyance for the products of combustion, and the draft gauge showing this last pass draft or differential draft, cannot be kept constant with the draft over the fire, as the boiler offers a variable resistance from time to time, necessitating an increase of draft through the boiler as the resistance to heat transfer increases. This can be had in one gauge of the multi-pointer, illuminated type. These instruments may be indicating only.

4—The manner in which the fuel is burned should be indicated by a CO_2 recorder, which is really the only reliable method of measuring the combustion. This instrument should be recording. It is desirable to have the draft over the fire recorded on the same chart with the CO_2, as the draft over the fire is one of the essential elements of combustion. It permits a study of the combustion conditions and the chief engineer can give instructions to the fireman as to just how to improve the combustion conditions. It seems short-sighted for a company to spend money,

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*Pittsburgh, Pa.

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thousands and thousands of dollars, for first-class stoker equipment, fans, superheaters, etc., and possibly buy the fuel on Btu. content, and then not have an indication or record of the combustion. The operator cannot determine the best combustion conditions by looking at the fire. He should have continuous analyses of the gases. The CO_2 record compared with other conditions of operation, such as draft, stack temperatures, etc., can be worked out in such a manner that the operator can, very quickly, become very expert in his operation.

5—The temperature of the flue gases is an indication of how thorough the heat transfer has been. It is desired to have this instrument recording for the benefit of study and correction of operation. The recorder will be an indicator also and for the operator's constant use. This instrument will be an indication that is very vital, for the reason that if you develop the highest per cent CO_2, etc., and yet are not getting the heat transfer, there is something radically wrong within the boiler. The boiler must be taken as a whole and not as an individual part, such as combustion zone, heat transfer zone, etc.

It is desirable to have all of these instruments mounted as nearly together as possible to minimize the travel of the operator; preferably on one board, but not necessary, as arrangements can be made in pretty nearly all plants whereby the instruments can be close enough together to enable the operator to see several instruments more or less simultaneously. It does not take long for an operator of any degree of intelligence to get thoroughly acquainted with the instruments and the value of each instrument.

A careful study should be made as to the relationship of each condition to the other. For a certain steam demand there should be a certain overfire draft, a certain wind duct pressure, certain CO_2 content, and upon these will depend the flue gas temperature as well as the steam output.

Often times a very inexpensive signal system, either by lights or bells, could be arranged from the power plant to the boiler plant to indicate when the load is going to be taken off or a greater load put on, so that the operator would have a chance to meet the requirements without too much loss of time and without sacrificing economy.

The above mentioned instruments, as stated, merely indicate or record conditions, but it is up to the operator, knowing these conditions, to meet the necessary changes in his operation for betterment. In addition to these instruments, boilers should be equipped with combustion control apparatus which can be calibrated for certain conditions and a certain pre-determined operation maintained. The proper kind of a combustion equipment that will stay in one position so long as the supply and demand of steam is equal, is productive of the very best economies. There is no operator, nor number of operators, who can change the damper in the uptake, in the wind duct, change the speed of the stoker, etc., just at the right time, as he or they are always behind actual requirements, and also cannot make these several changes simultaneously, but one at a time.

The most common elements resisting heat transfer are soot and scale. The boilers should be equipped with soot cleaners, the operation of which can be determined by the flue gas temperature. If the operator will study, for a few days, his flue gas temperature conditions under the verying load conditions, he will then be able to use the soot cleaners to the best advantage and will keep down the resistance to heat transfer to a minimum. Also, the plant should have the proper scale remover, the use of which can be determined from experience of each individual boiler plant, it depending upon the feed water conditions.

Feeding the water to the boilers is another important factor in the economical operation of a plant. The continuous method should be employed. The higher water level should be at light load and the lower water level at heavy load. Feed water systems should be arranged so that the distribution of water to the several bodies is as uniform as possible. The water should be delivered to each boiler at a pressure in excess of the steam pressure, which is usually accomplished by the use of an excess pump governor valve placed in the steam line to the pump or pumps, or in the discharge water line from the pump or pumps. However, this does not necessarily equalize the distribution of water to the several boilers. Improvement over this system can be made by the additional installation of an individual excess feed water pressure valve, just ahead of the feed water regulating valve. It should be connected to the individual boiler drum and set for the necessary excess pressure for that particular boiler.

It may be needless to add that the operator should be careful to see that the boiler setting is sufficiently tight to prevent the inleakage of air by the use of the proper boiler coating, which should be of a character to close the pores of the brick, as well as the joints or cracks in the joints betwen the bricks, etc., and around the steel work which joins the brick work.

It might be well to call attention, lest it may have been forgotten, to the questionnaire sent out by the Federal Fuel Commission during the recent World War. This questionnaire is worthy of being framed and placed in every boiler and power plant.

All of what has been said in this article can be summed up very briefly to the effect that the operator should be provided with all of the necessary instruments for visualizing the operation so that he can have more time to sit back, so to speak, and view the conditions and make a study of them and make the necessary correction for betterment. As a rule instruments and apparatus of the kind mentioned herein will pay for themselves very quickly.

The McKeesport Tinplate Company, McKeesport, Pa., has authorized plans for the rebuilding of the portion of its mill at Port Vue, near McKeesport, recently destroyed by fire with loss estimated at close to $100,000, including equipment. The construction is expected to cost close to a like amount.

The Republic Iron & Steel Company, Youngstown, Ohio, has authorized extensions in its coke division and will proceed with work at an early date. The installation will consist of an additional battery of 43 Koppers-Becker combination ovens, making a total of 247 oven units at the plant. The new ovens will have a carbonizing capacity of about 1,100 tons of coal per day, with a gross rating in this line at the plant, with all units, of 1,939,800 tons per annum. This is estimated to produce about 1,257,860 tons of metallurgical coke a year.

Mangan. Steel Shear Knives for Hot Work

By **EDWIN R. NORRIS***

IT has been the practice of some manufacturers of shearing machinery to supply shear knives of high speed or self hardening steel with all equipment intended for the cutting of hot steel products. A high speed steel specification appears on numerous drawings of Bloom, Billet, and Bar Shears. The origin of this specification was probably due to the idea that a steel having the quality of "red hardness" will not soften as quickly as a straight carbon steel when in contact with the hot products of the mill. However, water cooling for hot shear knives is always provided. It is common knowledge that water is not a suitable quenching medium for steels alloyed with Tungsten. If the shear knife reaches a temperature at which the "red hardness" quality can be of any benefit, the cooling water has a destructive action on high speed steel.

Users of shears have, in many instances, followed the precedent set by the manufacturers and have abandoned the older practice of using moderately high carbon Bessemer or Open Hearth steel for hot shearing. One of the penalties of the use of high speed steel is the excessive breakage of knives subject to shock in flying shears and in some designs of hydraulic shears. This is especially true of knives not of rectangular pattern, but shaped for the shearing of round or square bars.

During the year 1918, due to the high price of Tungsten steels, one shear in a mill in the Pittsburgh district was consuming steel at a rate of over $10,000 per year, and the mill operations were often jeopardized by inability to secure shipment of steel when needed. One small planer in the tool department was employed almost constantly in shaping knives for shears in the various mills. A research campaign was instituted, with the idea of reducing the excessive cost and relieving the tool shop of this burden. Shear knives purchased from organizations specializing in the manufacture, steels of various alloy, high and low tungsten, with low and high carbon, chrome steels, uranium steels, all were tried with various heat treatments and in the annealed state, in an effort to find a specification which might give reliable results. Some experiments developed lower costs but none gave the reliability desired.

The austenitic structure combined with the quality of toughness found in Hadfield steel of 11 to 14 per cent manganese content, suggested the use of this steel in shear knives. However, none of the prominent makers of manganese steel would entertain making castings for this purpose, and they declared manganese steel entirely unsuited for shearing purposes. When relieved of any responsibilty for the success of the experiment, one maker was induced to accept an order.

The first set of manganese steel castings gave six times the service of the best steel knives, used in an up-cut, duplex hydraulic shear. This result confirmed their adoption for this shear, and led immediately to a trial of the same material in knives for a flying shear, cutting sections from 1½ in. square to 3 in. round. The success on this job was even more pronounced. The frequent breakage through the narrow sections of tool steel knives was eliminated with the use of the unbreakable manganese steel, and the mental tension of the mechanical force, responsible for the shear knives, was relieved. The knives lasted so long that the shearmen and millwrights forgot them entirely. A flying shear has cut 50,000 tons of sheet bar with one pair of manganese steel knives which, upon examination, were found in condition for further service.

For the preparation of these knives, patterns are made to drawing sizes, with allowance for shrinkage of 5/16 in. per foot, but with no allowance for finish. Bolt holes and countersinks are cored and made amply large. The rough castings may be slightly warped when received from the foundry. They can be straightened cold under a steam hammer. A light grinding of both sides of the castings, on a surface grinder or on a planer equipped with tool post or angle plate grinder, to bring the thickness to correct dimension, is the only machine work required. No attempt is made to grind out all the low spots.

The following summary shows a comparison of production methods for the two types of shear knives:

	Tool Steel	Manganese Steel
Material	5 to 40 per cent excess over finished weight:	Net knife weight.
Cost	Varies with type of steel.	Under 20 cents per pound.
Machine Work	Plane all over, drill and countersink.	Light grinding on two sides only.
Heat Treatment	Quenching and drawing.	None.

Manganese knives of rectangular pattern, which have been worn so badly that they no longer make an acceptable cut, may be restored for further service. Soft steel plugs are machined to fit the bolt holes and countersinks and drilled axially to take a small bolt. The plugs are fastened into the bolt holes of the knives, which are heated to about 1,600 deg. F. and forged under a steam hammer to bring the worn edges back to a square condition. After forging the plugs are removed and the knives are reheated to 1,700 or 1,800 deg. F. and immediately plunged into cold water. A light grinding on the sides and possibly on the cutting edge, to remove high spots, puts the knives in condition for a second period of use. Care taken in forging may eliminate the grinding.

Small knives of irregular pattern could, in emergency, be reclaimed in a similar manner by hand forging, but in ordinary practice it would not be good economy.

Loman steel which is a modification of Hadfield steel and contains only 7 to 10 per cent of manganese instead of the usual 11 to 14 per cent, has not been used for shear knives, but it is possible its use would show good results. However, the martensitic structure of Loman steel renders it less ductile than manganese steel with austenitic structure, and it is probable the Loman steel would be lacking in shock resisting quality.

(Concluded on page 200)

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*Detroit, Mich.

Central Furnace to Sinter Dust

New Blast Furnace at Massillon Adopts Modern Economies

THE Central Furnace Company of Massillon, Ohio, has just contracted to have built a Dwight-Lloyd sintering plant in connection with its blast furnaces. Sintering is a reclamation process which has gained great popularity in the steel industry.

The engineering work, consisting of arrangement, general and detail plans and specifications, was done by the Freyn Engineering Company of Chicago, and contracts for structural steel for the building and for the complex system of hoppers, chutes and bins required in the sintering process, as well as a contract for the actual erection of the building and above mentioned equipment, have all been placed with the Morgan Engineering Company of Alliance, Ohio.

The sintering plant will be 18 ft. wide by 60 ft. long, and four stories high. A lean-to 13 ft. by 18 ft. will jut out from one side. Due to the nature of the sintering equipment the second and third floors will hold the main part of the apparatus. The first or ground floor will house the exhaust chamber, and the fourth floor will form a part of the tower. The building is to be of riveted construction, a total of over 130 tons of structural steel to be used.

The construction of the building itself is a comparatively simple job, the complicated work lying in the fabrication and installation of the nine hopper bins and chutes which alone will require nearly 30 tons of steel.

The exhaust chamber, the dimensions of which are to be 21 ft. 8 in. long, 7 ft. wide and 16 ft. 9 in. high, will be air tight up to a pressure of 1¼ lbs. per sq. in., and will use 6 tons of steel in its construction.

Great attention is being paid to sintering because of the economies that make it possible. The Central Furnace Company will use this plant to reclaim thousands of tons of fine iron ore dust, known as flue dust, that are ordinarily allowed to go unusued. The process of sintering changes the dust to a coarser form so that it can be used in the blast furnace. As dust, it would simply be blown into the air. Scale from the mill rolls will also be reclaimed in the same manner. Considering that iron ore costs in the neighborhood of five dollars a ton, and that sinter can be made for a small fraction of that amount, the dollars that can be coined out of what was formerly wasted may be readily imagined.

Of the flue dust carried from the furnace, about 70 per cent is recovered in dust catchers and 30 per cent in washers. At the Central Furnace Company, the flue dust is removed from the dust catcher system by a new type of sealed conveyor that prevents clouds of dust being thrown into the air. This dry dust is conveyed through suitable pug mills, mixers and belts, directly to the sintering machine. The dust carried in the washer water is recovered in the shape of a cake by means of continuous thickener and filter equipment, and discharged onto the dry flue dust conveyor.

This flue dust carries fine coke dust which, when ignited, serves to bring the flue dust up to a bright red temperature, fusing it into an agglomerated mass in which are imprisoned the gases of combustion of the coke dust. The product is a porous partially fused lumpy mass, highly susceptible to reduction in iron in the blast furnace.

The flue dust to be sintered is mixed with water to give it sufficient plasticity to prevent the dust from being sucked through the perforated pallets of the sintering machine. It is then fed into the machine, is carried under a gas flame where the coke dust is ignited, and then conveyed over a series of blast exhaust boxes by means of which blast is drawn downward through the ignited flue dust. The sintering thus started continues to the end of the machine, although during the end of the travel considerable cooling of the sintered mass obtains by means of the same air blast penetrating the top layer, now completely sintered.

The sinter drops off the chain into a slanting steel screening. Lumps slide onto and down through a chute to waiting cars by which they will be transported to blast furnaces. As the sinter passes over the screening, any loose dust that was not baked tight drops through, falling to a second carrier chain which starts it on a return trip to the mixing machine. Along with freshly mixed dust, it goes under the flame a second time.

In this way every bit of what was formerly regarded as unusable material and which cost blast furnace operators hundreds of thousands of dollars every year, is now to be made into iron. It is said the quality of this iron is every bit as high as can be secured from the natural lumps of ore that are put into the blast furnace.

This will be the first installation of sintering machine integral, so to speak, with complete dust recovery equipment at the blast furnace.

Drawings for the new building are being completed and actual construction will start about April 15th.

Commutation Troubles in D.C. Motors

(Continued from page 192)

This pitting of mica frequently occurs in undercut commutators whose slots between bars are not kept clean and which are permitted to become oily or greasy.

Pitted mica usually leads to more serious burning of the mica since dirt will collect more rapidly in such mica than on mica which is in good condition. The short circuit between two bars may come to have such a low resistance that excessive currents will flow in the short circuited armature coil, the heat thus produced being sufficient to char the insulation on the coil and to make the bars so hot that they take on a bluish-green color and spring away from their normal position.

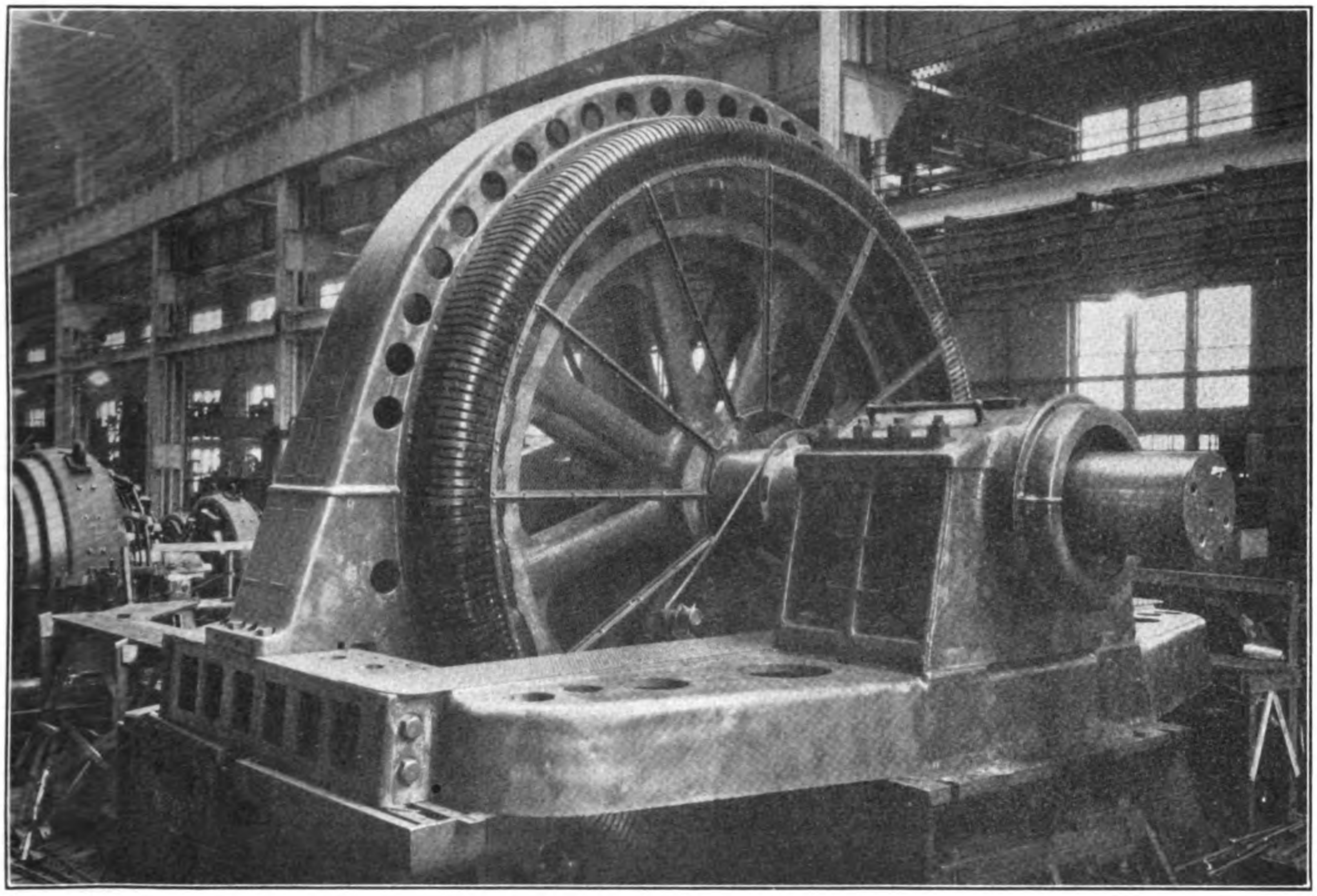
Summary.

Only the more simple and better understood causes of sparking troubles were considered in this article. This was done in order to place the stress upon the fact that certain rather definite symptoms point to each one of these causes of sparking and that the cause of the trouble may, therefore, be discovered by closely observing the various symptoms shown by the machine. More complex causes of sparking will be considered in following articles.

WITH THE EQUIPMENT MANUFACTURERS

Largest Industrial Motor

This 9,000-hp. synchronous motor has the highest continuous horsepower rating of any industrial motor in the world. It is shown in the shops of the General Electric Company preparatory to shipping to the McKinney Steel Company's River Furnace plant at Cleveland and where it will be direct connected to a Morgan continuous billet mill soon to be placed in operation. The mill will have ten stands of rolls and will be the first large steel rolling mill in the world to be driven by a synchronous motor, the usual practice having been to use an induction motor.



A New Continuous Regenerative Type Air Heater

Of interest to those concerned with heat economy is a recent deveopment in air preheaters developed by the Blaw-Knox Company of Pittsburgh. The heater is of the continuous flow, regenerative type, combining the best advantages of recuperation and regeneration.

While both air and waste gases have a uniform flow to and from the heater, a novel arrangement of valves and heating chambers in the heater itself permits an alternate passage of air and waste gases over plate heating elements. The heating elements consist of thin detached steel sheets spaced about ¼ in. apart, arranged vertically in three chambers, giving a large amount of effective heating surface per unit of volume.

A simple and almost noiseless mechanism provides a sequence of valve operation which enables air and waste gases to flow alternately, but in opposite direction through each of the chambers. Since heat transfer is caused by contact with the surfaces of the heating elements, deposits on the surfaces have practically no effect on heat transfer.

The leakage factor, always of much importance in work of this kind, is reduced to a minimum. In this heater, the leakage is practically limited to the chamber loss due to reversals, and accurate tests have shown that the total leakage can be kept as low as 2 to 3 per cent.

The counter flow of air and waste gases tends to materially reduce the deposit of dirt on the heating elements. Where necessary soot blowers are installed to facilitate soot-removal and cleaning. All parts of the heater as well as the heating elements are readily accessible for cleaning, repairing and replacement when necessary.

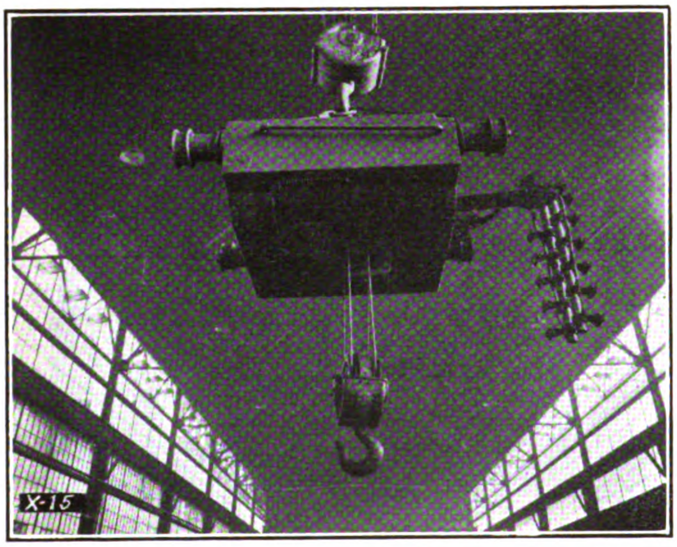
With this heater, it is practical to preheat air to within 150 deg. F. of the temperature of the incoming waste gases.

This heater is applicable to industrial heating furnaces as well as boilers and can be designed for handling waste gases up to 2000 deg. F. The heater is manufactured in a large range of sizes capable of heating from 5000 to 220,000 pounds of air per hour.

The Blaw-Knox continuous regenerative air heater is being manufactured in accordance with patents issued to Waldemar Dyrssen and owned by the Blaw-Knox Company. It is being marketed in the general industrial field by them and in the central station field by the Power Specialty Company of New York City.

Cleveland Crane Adopts New Wire Rope as Standard Equipment

Unlike the majority of radical engineer departures, or outstanding improvements to fundamental design, which are invariably met with apathy or opposition, the recently perfected methods for preforming the wires and strands in the manufacture of wire rope has met with almost immediate acceptance. That basic improvement in wire rope manufacture (the first in more than 100 years) has resulted in a rope that resists unraveling or high stranding and whose service life is so much greater than ordinary wire rope that in spite of the fact that it was introduced only about a year ago, the Cleveland Crane & Engineering Company has recently announced that all future Cleveland cranes would be equipped with rope made on this preformed tru-lay principle.



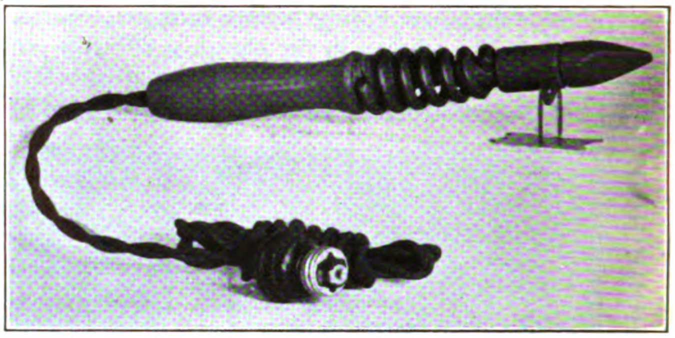
"This pre-formed rope," according to J. B. Shaver of the Cleveland Company, "together with the recent introduction of anti-friction roller bearings and chrome nickel steel gears, not only adds to operating efficiency and minimizes the accident hazard, due to the elimination of rope that will 'fly' or 'explode' when broken, but contributes to low operating expense."

The Braeburn Alloy Steel Corporation, pioneers in the manufacture of first quality high speed, carbon and alloy tool steels, announce the opening of general sales offices in the First National Bank Building, Pittsburgh, Pa., under the direction of H. Oliver Williams, vice president in charge of sales.

New Soldering Iron

The General Electric Company is now marketing a new soldering iron of light construction, designed to heat up quickly. This iron is made in standard sizes ranging from ½-in. to 1¼-in. tip.

Power consumption ranges from 70 watts for the smaller iron for light and intermittent use, to 350 watts for the larger size on heavy duty. The irons for heavy duty are provided with radiating stands for the purpose of maintaining the iron at the correct operating temperature when temporarily not in use. The rapid rate of initial heating is brought about by unusually good heat conduction between the heating element and the copper tip. Heat from the tip is prevented from reaching the handle by means of a special mechanical construction between the two, this being in the form of a spiral made from a steel rod. This also provides a rigid connection between the handle and tip.



Instead of mica, usually used for an electrical insulator in the heating unit of soldering irons of this type, the heating unit has an insulating powder so highly compressed that it becomes a good heat conductor and will withstand temperatures of more than 2,000 deg. F.

The iron is provided with a standard lead and connection plug. Its construction is simple, parts are few and all parts are equally replaceable.

Owing to the success which they have had with the two U. G. I. producers already installed, the Providence (R. I.) Gas Company has placed an additional order with the U. G. I. Contracting Company, Philadelphia, for the installation of a 10 ft. 6 in. U. G. I. producer of the latest type. This producer will incorporate the water jacket and low pressure steam features. The contracting company will also install with this produced one 5 ft. 10 in. diameter U. G. I. vertical waste heat boiler, designed for working pressure of 160 pounds. The producer gas coming over from the producer will pass through the waste heat boiler, giving up its sensible heat and thereby producing adequate steam for the operation of the producer.

In addition to the other equipment being installed at the new Harrison plant, the Public Service Electric & Gas Company has placed order with the U. G. I. Contracting Company of Philadelphia for a tar extractor installation having capacity of 15,000,000 cu. ft. of gas per day. The U. G. I. is already engaged upon the installation of eight 11-ft. sets at this plant, together with other equipment.

New Resistance Welders

The latest extension in General Electric welding activities is the entry into the resistance welding field. That company is now marketing two automatic resistance welding machines, one for straight seam work and the other for circular seams.

In resistance welding fusion is effected by heat generated by passing an electric current through the materials to be welded, augmented by pressure, whereas arc welding utilizes an arc or flame to melt the work, electrode or both. The General Electric automatic resistance welders consist of a framework for holding the work, a transformer for supplying current to the electrodes, movable electrode wheels and necessary control.

These equipments were particularly designed for welding the seams of light metal containers such as ice cream cans, drums, etc., and are suitable only for making lap joints with relatively thin metal. Among the advantages are the absence of fumes and open arcs making the use of masks unnecessary, and the fact that the operator requires no special welding training.

The welding speed obtained with these equipments varies from approximately 20 in. per minute to 100 in. per minute, depending on the nature and thickness of the material to be welded. Material up to a total thickness of ¼ in. may be accommodated.

A recent installation of this equipment is in the plant of the Solar-Sturgess Company of Chicago, where the circular seams of ice cream cans will be welded by this process.

The Pier process, for the use of soft coal in generators, continues to excite the active interest of gas engineers throughout the country, and the U. G. I. Contracting Company is receiving many inquiries relative to installations. The latest installation of the Pier process made by the U. G. I. is at the Bristol, Conn., plant of the Bristol & Plainville Electric Company, where this process is being installed in a 9-ft. set.

Mr. Clarence E. Guffin has been appointed Manager of Engineering Production of The Wellman-Seaver-Morgan Company, effective March 15, 1926.

The Wellman-Seaver-Morgan Company, Cleveland, Ohio, have just completed shipment of two W-S-M Revolving Car Dumpers to the Chile Exploration Company, Antofagasta, Chile.

Orders for car dumpers of the Revolving type, have just been received from the American Gas & Electric Company and the Anglo-Chilean Consolidated Nitrate Corporation.

This company has also received an order from the Chile Exploration Company for one 8-ton, rope operated, Ore Handling Bridge.

Allis-Chalmers business in Continental Europe will be handled through an organization recently incorporated as Allis-Chalmers (France), with headquarters at 3 Rue Taitbout, Paris. Mr. H I. Keen, who has been Manager of European sales through the Company's District Office in Paris, will be the Managing Director of the new organization.

The Company has maintained for many years an office in London, 728 Salisbury House, London Wall, F. C. 2.

Mr. John K. Desmond, formerly with Philadelphia District Sales Office of the Crucible Steel Company of America, has been appointed Philadelphia District Manager of steel sales for Henry Disston & Sons, Inc.

The New York Office of Raymond Bros. Impact Pulverizer Company, has been removed from 43 Broad Street to 342 Madison Avenue. Mr. S. B. Kanowitz, Eastern Manager, will be located at this new address.

The Smith Separator Company, Chestnut & Smith Corporation Building, Tulsa, Okla., has been appointed agent for the Homestead line in the states of Oklahoma and Northern Texas.

They will give especial attention to the Homestead refinery type valve for high temperature service and other Homestead products.

The Finney & Fuller Company, 147-149 Hotel Street, Utica, N. Y., have been appointed agent in the Utica district.

Employes Receive Recognition

(Continued from page 188)

Charles Deshler, technical supervisor, Harrison incandescent lamp works. Developed improved methods of photometering incandescent lamps.

Robert N. Falge, commercial engineer, Cleveland incandescent lamp works. Developed depressible-beam system of automobile headlighting.

Chester I. Hall, engineer, Development Laboratory, Fort Wayne. Developed the induction disc motor for the driving of talking machines, demand meters, time switches and similar devices.

Commercial.

Thomas L. Miller, salesman, central station department, Dallas office. Displayed unusual ability and initiative in certain novel and highly effective sales work.

William J. Bray, salesman, industrial department, Chicago office. Expanded his field of work by stimulation of interest in solution of engineering problems.

Alta R. Tanner, general salesman, San Francisco office. Provided effective method of drawing attention to the home electrical idea.

Leonard L. Asch, clerk, switchboard device sales, Schenectady. Devised film picturing construction and operation of products switchboard department, constituting a method of supplementing other sales effort.

Robert W. Adams, manager of Providence office. Proposed the personal rating sheets plan which has been adopted by the company.

Administrative.

Herbert L. Whittier, accountant, Erie works. Originated methods of estimating expense allowances to cover varying volumes of production.

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TRADE NOTES AND PUBLICATIONS

Mr. Walter Carroll, vice-president of Inland Steel Company, Chicago, Ill., has just published in the interest of the children of the workers in steel and iron, an interesting booklet under title "Making Steel."

Mr. Carroll tells the story in simple, direct, understandable language which any child or adult for that matter will appreciate reading. Application to the Inland Steel Company, will bring a copy without charge.

The increased popularity of the lift truck system for handling materials on platforms has brought forth some interesting developments. Several millions of various types of platforms are in use today. Many users have resorted to makeshift platform construction because it appeared that no standard construction was available.

The original cost and maintenance of these platforms represents the greatest drag on profits through their use in handling all kinds of materials with lift trucks. Various types have been suggested and marketed but none of them are possessed of the economical features for low maintenance cost which are found in the new improved Stuebing Steel-Bound platform.

This new type of platform was originated by Mr. W. R. Stuebing of The Stuebing Truck Company of Cincinnati, Ohio, and patents covering the construction and trademarks protecting the name have been granted. It has many distinctive features that make it unquestionably the most economical platform unit and the most universally applicable unit known. The principal feature of which is the method of clamping the wooden top between the jaws of the two steel angle rails which gives a viselike gripping action that results in extreme rigidity and strength.

This construction also makes the platform as flexible to changing requirements as a sectional bookcase, permits the instant application or conversion into bin types for handling small parts, stake types for long material, rack and table types, or the use of crane hooks where the load is to be handled overhead during certain phases of production.

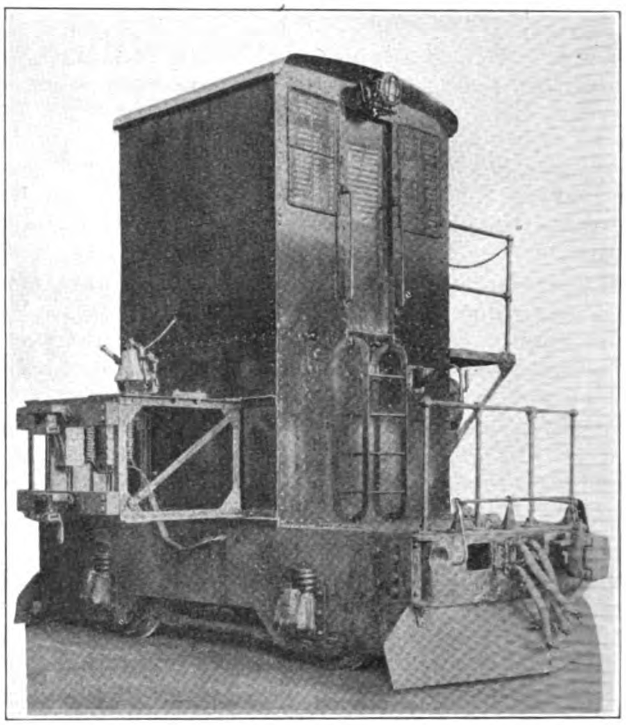
The design of this structure is so correct that it enables these platforms to withstand punishment, which would make kindling wood of ordinary types, and to carry with absolute safety 10,000 and even 20,000 lb. loads.

This Stuebing product is being made by the Stuebing-Cowan Company with main offices and plant at Cincinnati, Ohio, and the Cowan Truck Company plant at Holyoke, Mass., the latter company having been recently acquired by The Stuebing Truck Company.

Coke Quenching Locomotive

The locomotive shown in the accompanying illustration is used to draw coke quenching cars in the iron, steel and other industries where coke is made. The empty cars are drawn to the coke ovens and loaded, when they are drawn along a track under a quenching tower where water is sprayed on the hot coke to cool it. After this the coke is dumped.

The locomotive is specially designed by the General Electric Company to facilitate these operations. A platform on the side enables the locomotive operator to leave the enclosed cab for observation purposes. The cab is of the double-deck type and is sometimes lined with asbestos as a means of protection from the heat of the coke ovens. The equipment on the left on which the bell is mounted is the third rail collector, the third rails usually being suspended in the air. The lcomotive is supplied with air brake equipment which is used not only for braking purposes but also to supply compressed air to operate the dumping mechanism on the quenching car.



A. J. McFarland, general manager Follansbee Brothers Company, is just recovering from an illness of several months' duration.

Manganese Steel Shear Knives

(Continued from page 195)

In general, manganese steel shows superiority over tool steels for hot shearing, in less material required, in lower cost per pound, in less labor and machine work in preparation, in requiring no heat treatment, in much longer service with no hazard of breakage, and in possibility of simple and cheap resoration for further service. Manganese steel shows superiority over Bessemer and open hearth steels in all of the above features except that of first cost of material.

Mechanical Furnace Tapping

Occasionally a new piece of machinery appears which operating conditions seems to fully justify. This is particularly true where the machine simplifies, safe-guards or standarizes a strenuous task in the daily routine of blast furnace or open-hearth practice. Such was the mud-gun; such was the automatic stoker.

A recent bulletin issued from Columbiana, Ohio, describes the Mullen Blast Furnace Tapping Machine.

The machine consists of a frame with guides, and an air cylinder which imparts to the drill a reciprocating motion. At each return stroke the drill revolves about one-fifth turn. The cylinder and drill are fed forward by means of d.c. reversing type motor through pinion and gear attached to feed screw. An automatic locking device synchronized, with feed motor, locks the reciprocating cylinder to guides, and thus eliminates the work on main screw while drilling.

The operation is simple. When ready to cast, the machine is swung to front of furnace by crane, the locking grips of machine are placed over brackets on iron trough, the operator balances the machine downward and closes grips from his station by three-way air valve. The operator opens throttle on air line, and machine starts drilling. To enable the operator to regulate feed to suit varying degrees of hardness in different sections of hole, a dial is placed on machine which indicates at all times the amount of feed required. When iron is struck, the operator releases lock from trough brackets and reverses motor, the machine balances to horizontal position, air is admitted to small cyliner and crane swings machine into space provided for parking, the entire operation of tapping being performed by one man.

As might reasonably be expected with the first design of a machine for new purposes, the ideal machine was not produced with the initial attempt, not even with the second; but the results convinced furnacemen that the efforts were in the right direction. As continued operation of machine developed the fact that improvements could be made to advantage in design, material, and methods of operation, these improvements were made.

The machine as produced today is a simple, rugged and dependable piece of apparatus, and is operated by any of the men at the front.

New Type of Merger Needed

A type of merger much needed currently in American industry is a merger of projects before they become organized into companies, declares John F. Sherman, President of the Sherman Corporation.

"Factories and mills in every line are heavily overcapacitated according to surveys which we have just made," says Mr. Sherman, "Instead of working 300 days a year thousands of employees are working 200 or 150. Companies are carrying the burden of unused floor space, of machinery not fully employed.

"At the same time, new companies are being formed to turn out products and sell them. Many of these products could be manufactured in plants now suffering from over-capacitation thus increasing employment, cutting costs and eliminating waste of capital.

"There is little if any economic justification for many new companies. They waste millions in capital, frequently benefitting only that small portion of society which profits by financial promotion. They originate in the desire of some individual to make a fortune out of a new alarm clock, a reversible rubber heel, an automatic window opener, or some other products which we could very well get along without. Many of these ideas and projects can be used to absorb our present industrial overcapacitation."

Recent analyses by The Sherman Corporation in industry indicate that the overcapacitation problem is acute and requires intensive co-ordination. A new division has been created by the company to help alleviate these conditions by bringing together new products and plants having facilities to make them; to analyze market limitation and possibilities of both established and new products, and to effect closer coordination between production and selling functions of industry.

Mr. P. E. Floyd has been appointed by the Ludlum Steel Company, Watervliet, N. Y., as manager of sales in charge of their Chicago office and warehouse. He succeeds Mr. Edwards, who has been transferred to the Southern territory with headquarters at Houston, Texas.

Frank McGough, formerly steam engineer of Weirton Steel Company, has resigned to assume the same position with Follansbee Brothers Company.

The Bliss "Cluster" Mill

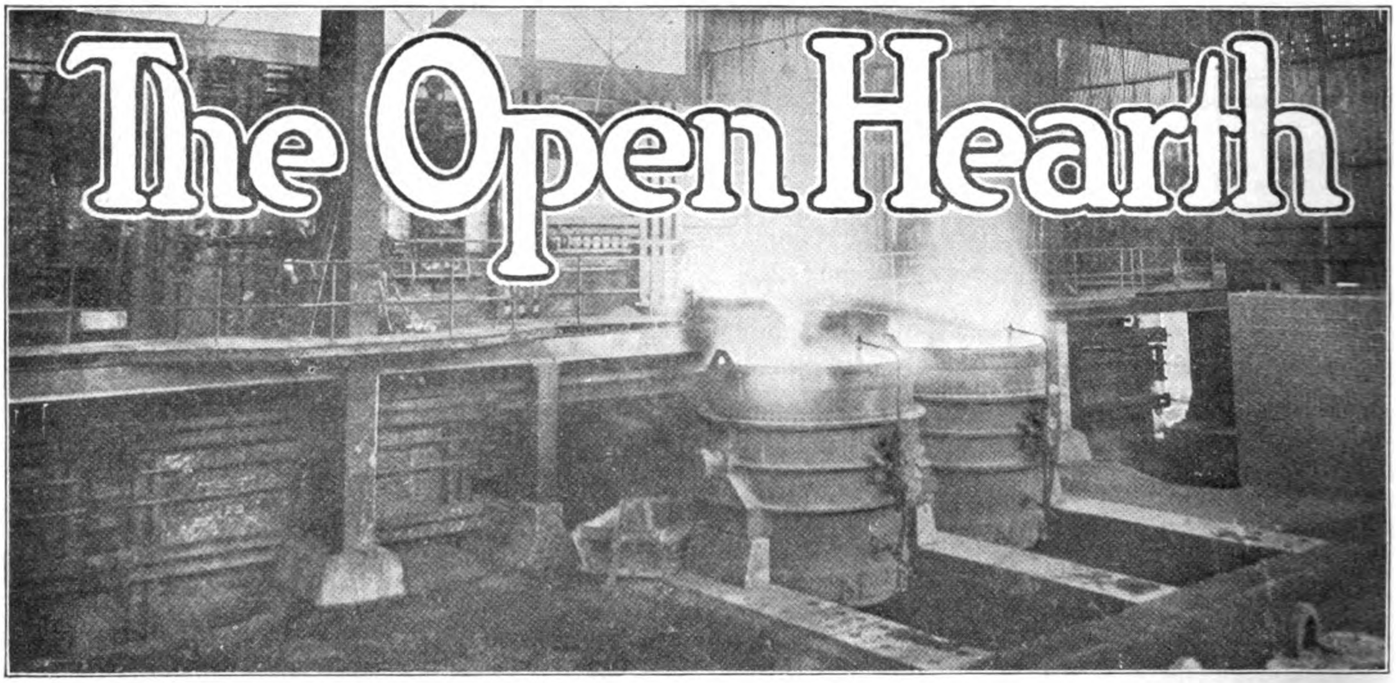
(Continued from page 180)

in place of two neck bearings as would be the case if only one backing up roll were used.

The main products of this mill are sheets of highly finished surface. The mill is capable of rolling up to 36 in. wide—but the construction is such that the mill can later on be widened out so as to eventually roll sheets up to 42 in. wide. On account of the stiffness of the mill, sheets of great accuracy are produced. The mill is also arranged for rolling strip in long lengths up to 18 in. or 20 in. wide.

The mill so far has more than come up to expectations. It has increased the range of cold rolling from 20 in. wide strip to practically any width desired and has proven equally applicable to metals other than Monel Metal and nickel, such as high and low carbon steels. That the International Nickel Company, who have only recently entered the field of rolling metals, should be responsible for the bringing out of this new type mill, and process of rolling highly finished sheets, is greatly to their credit.

In addition to the utility value of Monel Metal due to its resistance to corrosion and great durability, its appearance, which when brought to a high finish is comparable with nickel plating, has made it extremely valuable for purposes such as soda fountain construction, restaurant equipment, automobile trim, radiator shells, showcase and store front construction, and many other uses. The Bliss cluster mill has undoubtedly made it possible to adapt Monel Metal and nickel to these markets. The first mill is now booked to capacity and a duplicate mill is under construction.



The Open Hearth

Frank H. Colladay has been appointed district sales manager, Braeburn Alloy Steel Corporation, in charge of the New York District. Mr. Colladay has resigned as New York manager of sales of the Trumbull Steel Company, and he has been affiliated with the steel industry all his life, and as a result is well-known to the steel trade. He is a member of the American Iron and Steel Institute, Engineers' Club, Machinery Club of New York and the Indian Harbor Yacht Club of Greenwich, Conn. The New York District sales offices of the Braeburn Alloy Steel Corporation are located in the Grand Central Terminal Building.

T. H. Rogers, formerly general superintendent of the Follansbee Brothers West Virginia plant, is now associated with Weirton Steel in the automobile sheet division.

R. H. Stuhler, formerly general superintendent, McKeesport Tin Plate Company, has resigned after eight years' activity with this organization.

The Donner Steel Company, Buffalo, N. Y., has plans under way for extensions and improvements in its plant to include the installation of additional equipment for increased production. It is purposed to install a new Heroult electric furnace of 25 tons capacity for expansion in the line of special steels and alloy materials, particularly designed for use in the automotive industry. This installation with auxiliary equipment is expected to be made in about 90 days, and will be placed in service immediately thereafter. For charging the new furnace, hot metal direct from the blast furnaces will be utilized. Other extensions will be made about the same time.

James W. Galvin has resigned as superintendent of steel works, Steubenville plant, Wheeling Steel Corporation, to give his attention to personal interests in Chicago.

George E. Wisener will retire on July 1 from his position as general superintendent of the Mingo and Bellaire, Ohio, works of the Carnegie Steel Company, and at the same time also withdraw from active business, and thereafter devote his time to leisurely pursuits. He has been connected with the Carnegie company for 39 years.

The new blast furnace at the Indiana Harbor plant of the Inland Steel Company is slated to be blown in early in April.

Ollison Craig has been appointed consulting engineer of Riley Stoker Corporation, Worcester, Mass.

M. Schiller has been elected vice-president in charge of accounts and purchases, Superheater Company, 17 East Forty-second Street. W. F. Jetter becomes treasurer and assistant secretary; Bard Browne was appointed assistant to vice-president in charge of sales and services, and T. F. Morris, assistant secretary and assistant treasurer.

A. R. Johnson has been appointed Chicago district sales manager of the Trumbull Steel Company, Warren, Ohio, with offices in the Continental and Commercial National Bank Building.

L. G. Pearce, formerly chief draftsman Mackintosh-Hemphill Company, Pittsburgh, has been appointed plant engineer, Pittsburgh Crucible Steel Company, Midland, Pa.

The Keystone Drawn Steel Company, Spring City, Pa., recently formed with a capital of $300,000, has plans under way for the operation of a new steel fabricating works. It is expected to proceed with the project at an early date, with estimated cost placed at $100,000, with equipment. The new company is headed by Isaac D. Hetzell, 322 Richmond Street, Philadelphia, Pa., and associates.

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NEWS OF THE PLANTS

The Columbia Steel Company, Standard Life Building, Pittsburgh, Pa., recently organized under state laws to take over and consolidate the Columbia Steel Company, Elyria, Ohio, and the Forged Steel Wheel Company, Butler, Pa., has plans under way for extensive additions in the present Butler works of the last noted organization. The project will consist of a new 30-in. hot mill and 30-in. cold strip mill, with new buildings and other machinery for different branches of production. The new mills will have a rated capacity of 20,000 tons per month and will represent the widest type of units of this character up to the present time. The production will be designed largely for the automotive industry, being equivalent to the grade of sheets used for the manufacture of automobles and not heretofore obtainable in the width noted. The expansion program is estimated to cost in excess of $2,000,000, and will include improvements and equipment replacements in existing buildings and machinery at the Butler plant. This consists of ten basic open hearth furnaces with capacity of 70 tons; slabbing mill; 18-in. merchant mill; dolomite sintering plant; machine shops, wheel finishing plant and auxiliary structures. The present mill at Elyria will also be continued in service; this plant has been specializing in the production of high grade cold strip steel and will be maintained for this character of production. It is understood that tentative plans are being considered for extensions and betterments in this works, with view to increased output. The new company is headed by H. M. Naugle, president; A. J. Townsend, vice president and general manager; and K. R. Jensen, all of whom have heretofore been connected with the Columbia Steel Company of Elyria. Barton Shover, Oliver Bldg., Pittsburgh, is engineer for the Butler mill project.

The Central Steel Company, Massillon, Ohio, continuing its expansion program with a view to developing an entirely self-contained operating unit, is arranging for the early installaton of a by-product coke oven plant, with complete by-product equipment for the production of benzol and affiliated products. The unit will consist of 49 ovens of Koppers-Becker combination type, with carbonizing capacity of about 1,350 tons of coal per day. It is estimated that this will yield close to 345,000 tons of metallurgical coke per annum. The installation will include coal-handling machinery and complete auxiliary apparatus. W. E. Hartman is consulting engineer for the Central Company, in charge.

The Sharon Steel Hoop Company, Sharon, Pa., has plans under way for improvements at its plant to include the complete electrification of the present 8-in. and 10-in. mills, replacing present steam-operated equipment. The work will also include a new gas-producer plant and other general betterments for increased production, and is estimated to cost close to $500,000, with equipment.

The Peerless Malleable Iron Company, Toledo, Ohio, has been organized to take over the former local mill of the United States Malleable Iron Company, recently secured at a receiver's sale by Ira L. Houghton, Toledo, and associates for a consideration of $418,931. The new company is capitalized at $250,000, and plans for betterments in the existing plant to bring to a desired point of production and efficiency. Mr. Houghton was vice president and general manager of the previous United States company, and will head the new organization, which will take over the property at once and begin operations.

The Walter Bates Steel Corporation, Gary, Ind., recently organized by Walter A. Bates and associates, is perfecting plans for the early erection of a new local steel fabricating plant, specializing in the manufacture of steel towers, poles, steel sash and kindred products. Plans have been completed for the initial unit, consisting of a main one-story building 150 by 200 ft.; closely following, a second building, 100 by 200 ft., will be erected, as well as a number of smaller subsidiary structures. Contract for the structural steel framework has been let to the American Bridge Company, Chicago. Mr. Bates will be president of the new company; he was formerly connected with the Bates Expanded Steel Truss Company, East Chicago, Ind. There will be no connection between the two concerns. L. D. Stapleton, Jr., will be vice president of the new company, and B. C. Johnson, secretary.

The Mobile Steel Company, Mobile, Ala., has plans nearing completion for the construction of a new addition to its mills, on site selected at Knox and Conception Streets. It will be one-story, estimated to cost in excess of $100,000, and will be equipped to provide for large increase in capacity. It is expected to begin work at an early date. A list of equipment to be installed has been arranged. William McIntosh is president.

The American Steel & Wire Company, Chicago, Ill., is continuing its expansion program to include other works of the company in addition to those at Worcester, Mass., and Cleveland, Ohio, for which plans recently were perfected. It is proposed to begin work at an early date on a new mill at Gary, Ind., comprising a number of units, with power plant and auxiliary structures, reported to cost close to $10,000,000, with machinery and operating equipment. The new plant is expected to provide facilities for the employment of about 5,000 to 6,000 operatives.

The Eberman Steel Company, 1103 Eighteenth, N. W., Canton, Ohio, operating a steel fabricating works, has completed plans for a new unit on Allen Avenue, S. E., to be equipped for expansion in the fabricating department. It is estimated to cost close to $100,000, including machinery. Work will begin at an early date.

BY-PRODUCT AND CHEMICAL NEWS

The Koppers Company has been awarded a contract by the Republic Iron & Steel Company, Youngstown, Ohio, for one battery of 43 Becker type combination ovens to have a capacity for carbonizing approximately 1,100 tons of coal per day.

The Koppers Company has been awarded a contract by the Central Steel Company for a by-product coke plant at Massillon, Ohio. This plant will consist of 49 Becker type combination ovens having a carbonizing capacity of approximately 1,350 tons of coal per day, together with the necessary by-product and benzol equipment and coal and coke handling plant.

New President for Coke-Gas Company

Announcement was made recently at a meeting of the board of directors of the Chattanooga Coke & Gas Company in New York the past week that T. R. Preston, president of the Hamilton National Bank of Chattanooga, was elected president to succeed W. T. Wolle, who died recently. The directorate is composed of W. M. Ross, J. O'Brien, O. Walsh, W. E. Early, J. A. McCann, G. F. Meehan and T. R. Preston.

It is stated that the merger of the Chattanooga Coke & Gas Company of Nashville, the Bon Air Coal & Iron Corporation and the Bon Air Chemical Company was to become effective about April 1. The new corporation will be known as the Tennessee Products Company and will have a capital of approximately $15,000,000. The Wrigley interests of Chicago own the controlling stock in the corporation, it is stated.

Koppers Re-elects All Officers and Directors

At the annual meeting of the Koppers Company all officers and directors were re-elected. The following changes were made in some of the subsidiary companies:

The Kopper Construction Company: H. B. Rust, chairman of the board; W. F. Rust, president; C. J. Ramsburg, vice president; Joseph Becker, vice president; Harold Doolittle, vice president; Halfdan Lee, vice president; J. I. Thompson, vice president.

T. G. Janney, manager of the Chicago By-Product Coke Company, was elected vice president and manager. D. MacArthur, manager of the Seaboard By-Product Coke Company, was elected vice president. J. T. Tirney was appointed manager of the Seaboard By-Product Coke Company. E. L. Smith, manager of the Minnesota By-Product Coke Company, was elected vice president and manager. F. H. Beebe, manager of the Western Gas Construction Company, was elected vice president and manager. J. P. Williams, manager of the Melcroft Coal Company, was elected vice president and manager. J. M. Forker, formerly purchasing agent of the Koppers Company, was elected vice president and manager of the American Tar Products Company. D. M. Craig was appointed assistant to president, the Koppers Company. F. W. Sperr, Jr., was elected director of research, the Koppers Company. W. L. Williams was appointed purchasing agent, the Koppers Company.

In the wonderful enhancement of Florida real estate values, together with the great influx of new population, Tampa stands in the forefront and is receiving great attention from those having keen insight and clear judgment of values.

Because of Tampa's rapid and substantial growth, the Tampa Gas Company has had to keep pace with the large demands being made upon it. During this winter the daily sendout has reached such a point that the installation of additional equipment has become imperative. The Tampa Gas Company has therefore called upon the U. G. I. Contracting Company of Philadelphia to furnish and install equipment that will make the Tampa Gas Works an object of interest to any gas manager who may visit them.

The new equipment to be installed will include two 11-ft. U. G. I. cone top set of carburetted water gas apparatus, which will include the latest improvements brought out by the company such as the Model B automatic control and equipment for the utilization of exhaust steam in the apparatus including Smoot accumulators. There will also be installed in each set as well as in present 9-ft. sets the Pier process whereby bituminous coal can be used as generator fuel with maximum results and efficiencies.

Connected to the two 11-ft. sets will be a 6 ft. 9 in. U. G. I. vertical waste heat boiler which will form a valuable adjunct to the present boiler plant and by saving the sensible heat of the blast gases, will produce considerable boiler cost economies.

The new apparatus will increase the capacity of the plant by 7,000,000 cu. ft. per day.

In addition to the above, many other improvements are to be made to the manufacturing plant and property. To house the new carburetted water gas apparatus, a new generator house embodying the latest ideas in building construction will be erected. A new purifying plant will be installed, capable of handling the increased make of gas with adequate provision for future growth. A complete fuel handling system will be installed that will be capable of handling and storing about 5,000 tons.

To meet the increased steam requirements, a new 800-hp. water tube boiler plant will be installed, complete with all accessories. Likewise, a new station meter, pusher, booster and compressors are to be installed.

To take care of this large additional demand, about 50 miles of new mains are to be laid, making a total of about 250 miles of main serving the city. There will also be about 6,000 new meters and services installed. To take care of this increased business, the company's shops are to be doubled in size and capacity.

The total amount of money to be spent by the Tampa Gas Company in these improvements is about $1,500,000.